Niveau(x) d'enseignement: 3 Numéro EDUQ : 8370873
Centre d'intérêt: 530

Brien, Robert.

Directed and spontaneous use of learner strategies in concept and rule learning / by Robert Brien. -- [Québec (Province)?] : R. Brien, 1977.
ix, 183 f. : graph. ; 28 cm.

"A dissertation... in partial fulfillment of the requirements for the degree of Doctor of Philosophy". Bibliographie: f. 175-181.

Cote Dewey: / Cote LC: /

Descripteur(s): *Stratégie *Méthode d'apprentissage *Méthode d'enseignement *Sciences *Primaire (Niveau)

Identificateur(s) de sujet: *Processus d'apprentissage

L'objet de cette recherche est d'évaluer l'effet de la sélection par l'élève des étapes du déroulement du cours ("instructional events") et des stratégies d'apprentissage sur le rendement dans l'apprentissage de concepts et de règles définis. Plus spécifiquement, l'étude tente d'évaluer l'aptitude des élèves du niveau primaire à déterminer par eux-mêmes les étapes d'un cours en vue de maîtriser des concepts et des règles définis; elle tente aussi de déterminer dans quelle mesure cette aptitude peut être augmentée au moyen de brèves indications sur les conditions d'apprentissage.

L'expérimentation s'est déroulée auprès de 24 groupes expérimentaux totalisant 120 élèves de cinquième année et de sixième année de l'école l'Escale, à Charlesbourg. On a procédé selon une équation factorielle de 2x3x4, dans laquelle la première variable est la préparation à l'apprentissage (avec ou sans indications sur les conditions d'apprentissage), la seconde variable est le type de contrôle des étapes (contrôle par l'élève, contrôle systématique ou détermination au hasard) et la troisième variable est constituée par les classes, soit quatre reproductions des groupes correspondant aux variables précédentes. La matière que les élèves ont à apprendre est une science imaginaire, la science des systèmes xénogrades, où des lois décrivent les relations entre un noyau et ses satellites. On a utilisé des tests en cours d'étude, un post-test, un test de rétention et un test d'attitude.

Il apparaît que, en ce qui concerne la maîtrise et la rétention des règles scientifiques, une exécution séquentielle des processus d'apprentissage est supérieure à une exécution au hasard ou au contrôle de l'élève sur la mise en oeuvre de ces processus. Les résultats de l'expérience suggèrent qu'on pourrait apprendre aux enfants à activer leurs propres processus d'apprentissage dans un ordre optimal défini mais que l'effet positif de la stratégie d'apprentissage qui en résulte pourrait reposer fortement sur la familiarisation et la pratique de la stratégie d'apprentissage.

Type de document: r
Région(s) administrative(s): 03
Auteur de l'analyse: jr

E D U Q 8370873

E D U Q 8370873

THE FLORIDA STATE UNIVERSITY

COLLEGE OF EDUCATION

DIRECTED AND SPONTANEOUS USE OF LEARNER STRATEGIES IN CONCEPT AND RULE LEARNING

By
ROBERT BRIEN

A Dissertation submitted to the Area of Instructional Design and Personnel Development, Program in Instructional Design and Development, in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

Approved:

Robert M. Gagné
Professor Co-Directing Dissertation

William Hannon
Professor Co-Directing Dissertation

Walter Dick

H W Stafford

J. L. Bond
Dean, College of Education

August 1977

ABSTRACT

The purpose of the present study was to evaluate the effect of (a) brief instruction on a learning strategy and (b) type of learner control of instructional events upon performance in the attainment of defined concepts and rules by sixth-grade children.

A 2 x 3 x 4 factorial design was used in the experiment. One hundred and twenty children of grade six were randomly assigned to the 24 experimental groups.

The experiment took place on two consecutive, regular school days. On the first day, half of the children were taught the conditions of learning for the attainment of rules. On the second day, all children engaged in the learning of a fictitious science, the science of Xenograde systems. Within-program tests, a posttest, a retention test and an attitude test were administered. Completion time and patterns of choice of events were recorded.

A significant interaction of the factors preparation for learning and type of control occured on the retention test. The same trends were observed on the within-program tests, the posttest, and with completion time.

Children who were provided with systematic presentation of events and no instruction on the conditions of learning scored significantly higher than the children who were provided with random sequences of events or who had control over their learning. Children who were provided with systematic presentation of events and with instruction on the conditions of learning scored significantly lower than the children who were provided with random sequences of events or who had control over their learning.

It was concluded that with respect to the attainment and retention of scientific rules, a sequential execution of learning processes is superior to a random execution or learner control over the execution of such processes. Results of the experiment suggest that children could be taught to activate their own learning processes in a definite optimal order but that the positive effect of the resulting learning strategy might rely greatly on the familiarity and practice of the learning strategy.

ACKNOWLEDGEMENTS

The writer is deeply grateful to Dr. Robert M. Gagné who has provided invaluable encouragement, ideas, and constructive criticism all along the writing of this dissertation. The writer also wants to thank the other members of the dissertation committee Dr. Wallace H. Hannum, Dr. Walter Dick, and Dr. Howard W. Stoker for their kindly assistance and support.

Appreciation for permission to conduct this study in two elementary schools of Charlesbourg, Quebec, Canada is given to Mr. Jean-Paul Paradis and Mr. Raymond Lafrance respectively, principal at Parc Orleans and L'Escale elementary schools. Without the cooperation of Mr. Alphonse Gagne, Guy Fleury, Jacques Tessier, Raoul Poulin, Paul-Guy Boucher, Jacques Grenier, Paul-Henri Sevigny, and Miss Josee Dupont, classroom teachers, this study could not have been completed. Thanks to Dr. Gerard Scallon, Dr. Jean-Jacques Bernier, and Dr. Monique Aubin for technical assistance during the conduct of the experiment and to Mrs. Elaine Wright for the typing of the dissertation.

The writer thanks his wife, Liette, for her unfailing encouragement and his sons Stephane and Sebastien for their patience.

TABLE OF CONTENTS

	Page
ABSTRACT	ii
ACKNOWLEDGEMENTS	iv
LIST OF TABLES	vii
LIST OF ILLUSTRATIONS	ix
Chapter	
I. INTRODUCTION	1
II. RELATED STUDIES AND THEORY Studies of Learning Strategies Learner-Controlled Instruction Gagné's Theory of Learning	3
III. STATEMENT OF THE PROBLEM Gagné's Model of Learning Experimental Questions Hypotheses	20
IV. METHOD Design Subjects Materials Procedure Evaluation Instruments	27
V. RESULTS Within-Program Performance and Time Posttest and Retention Test Performance Attitude Test Performance Analysis of Patterns	37
VI. DISCUSSION AND IMPLICATIONS Optimal vs. Random Sequence, No Preparation for Learning	56

TABLE OF CONTENTS--Continued

Chapter Page

Learner Control vs. Systematic Control, No Preparation for Learning
Preparation for Learning
Learner Control, With and Without Preparation for Learning
Systematic Control, With and Without Preparation for Learning
Implications for Future Researches

APPENDIXES 69

BIBLIOGRAPHY 174

VITA 182

LIST OF TABLES

TABLE		Page
1.	Reliabilities of Within-Program Tests, Posttest, and Retention Test.	35
2.	Within-Program Tests Group Means and Standard Deviations as a Function of Preparation for Learning and Type of Control.	38
3.	Completion Time Group Means and Standard Deviations as a Function of Preparation for Learning and Type of Control.	38
4.	Analysis of Variance Summary for Within-Program Performance Scores as a Function of Preparation for Learning and Type of Control.	39
5.	Analysis of Variance Summary for Completion Time as a Function of Preparation for Learning and Type of Control.	40
6.	Posttest Group Means and Standard Deviations as a Function of Preparation for Learning and Type of Control	43
7.	Analysis of Variance Summary for Posttest Performance Scores as a Function of Preparation for Learning and Type of Control	44
8.	Retention Test Group Means and Standard Deviations as a Function of Preparation for Learning and Type of Control.	46
9.	Analysis of Variance Summary for Retention Performance Scores as a Function of Preparation for Learning and Type of Control	47
10.	Analysis of Variance for Simple Effects of the Factor Type of Control for Retention Performance Scores	48

LIST OF TABLES--Continued

TABLE		Page
11.	Analysis of Variance for Simple Effects of the Factor Preparation for Learning for Retention Performance Scores	48
12.	Attitude Test Group Means and Standard Deviations as a Function of Preparation for Learning and Type of Control	50
13.	Analysis of Variance Summary for Attitude Test Scores as a Function of Preparation for Learning and Type of Control	51
14.	Selection of Particular Patterns in Groups A and B	54

LIST OF ILLUSTRATIONS

FIGURE		Page
1.	Relation of the learning processes to the instructional events as described by Gagné (1974)	22
2.	Basic research design of the experiment . . .	28
3.	Mean number of correct responses in within-program tests as a function of preparation for learning and type of control	41
4.	Mean time required to complete the course as a function of preparation for learning and type of control	42
5.	Mean number of correct responses in posttest as a function of preparation for learning and type of control	45
6.	Mean number of correct responses in retention test as a function of preparation for learning and type of control	49

CHAPTER I

INTRODUCTION

The purpose of this study was to investigate the effects of student selection of instructional events and suggested learning strategies upon performance in the learning of defined concepts and rules. Previous research related to forming independent learners has generally investigated either the effects of direct teaching of learning strategies or learner-controlled instruction. The following study attempted to integrate into its overall design the methodologies used by investigators of learner-controlled instruction (Campbell, 1964; Mager, 1961; Newkirk, 1973), direct teaching of learning strategies (Rohwer, 1974; Salatas and Flavell, 1975), and the conceptual model proposed by Gagné (1974) of the interrelationships between instructional events and learning processes. More specifically, the study was an attempt to evaluate the ability of students of the elementary level to manage sets of instructional events for the attainment of defined concepts and rules, and to determine to what extent this ability could be improved by providing brief instruction on the conditions of learning.

The evolution of increasingly complex systems and subsystems in modern societies has underlined the problem of developing the individual who has to perform in these subsystems. The amount and complexity of the required behaviors and the limited time for their mastery has become a matter of concern for both learners and designers of instruction. In this context, the development of independent learners has been suggested by many educators as a fundamental goal of an educational system. In fact, both pedagogical and economic reasons have been put forward by the proponents of learner-controlled instruction and direct teaching of learning strategies. From a pedagogical point of view it has been proposed that providing the learner with adaptable learning environments and/or teaching him learning strategies would result in better performance and attitudes toward learning (Campbell and Chapman, 1967; Grubb, 1968; Mager, 1961). From an economic point of view, it has been suggested that providing learners with control over a course of study would reduce the time to complete the course and also the time for design and development of the course (Campbell and Chapman, 1967; O'Neil, 1973; Rothkopf, 1970).

CHAPTER II

RELATED STUDIES AND THEORY

Previous studies have used different methodologies to investigate the effects of direct teaching of learning strategies and learner-controlled instruction. In the case of learning strategies, investigators have studied the existence of general "inspection behaviors" in the learning of prose materials (Rothkopf, 1963, 1966, 1968, 1970). Others have attempted to assess and act directly upon specific learning processes such as rehearsal (Belmont and Butterfield, 1971; Flavell, Beach and Chinsky, 1966), encoding (Rohwer, 1974; Tversky, 1973), and retrieval (Ritter, Kaprove, Fitch and Flavell, 1973; Salatas and Flavell, 1975). With regard to learner-control of instruction, investigators have generally provided learners with adaptable learning environments and have compared performance and attitudes of students who were provided or not provided with such environments (Judd, 1972). In contrast to studies involving direct attempts to influence the execution of learning strategies, the studies of learner-controlled instruction have generally employed a "learning by discovery" approach (Campbell, 1964; Merrill, 1975; Merrill

and Boutwell, 1973). The following survey of literature summarizes these two major trends, and, in addition, the work by Gagné which provides the theoretical framework for the design of the present study.

Studies of Learning Strategies

Mathemagenic Activities

In 1963, Rothkopf proposed a conceptual model for learning from written sentences and self-instructional programs. The central point of the model was "that a class of activities called inspection behaviors plays a critical role in determining the effectiveness of self-instructional programs" (Rothkopf, 1963, p. 31).

In Rothkopf's model, the associations which enable the learner to demonstrate the training objectives were conceived as the output of the execution of these inspection behaviors. These inspection behaviors or "mathemagenic activities" included "both rehearsal-like activities and responses chaining or problem solving" (Rothkopf, 1963, p. 36).

In one experiment, Rothkopf (1966) attempted to demonstrate the existence of inspection behaviors. University students (n = 159) were presented with twenty pages of prose material and instructed that they would be tested on the contents after having read it. Five experimental treatments and one control group were used in the

experiment. Four groups were asked questions either before or after reading of paragraphs, and they were provided with, or not provided with, knowledge of results. Two other groups read the text without receiving such questions. One of these groups was given directions on being attentive to all facts presented in the text, while the other served as a control. The material was designed in such a way that the questions following the paragraphs and those of the posttest assessed different capabilities. Thus, for students who were provided with questions following paragraphs, higher scores on the posttest were taken as evidence of the activation of inspection behaviors by such questions. Scores on the posttest showed no significant difference for students who were presented with questions before paragraphs (with or without knowledge of results) and those of the control group. Scores of students who received questions after the paragraphs (with knowledge of results) and those who received hortatory directions were equivalent, but both were significantly superior to those of the control group. Rothkopf concluded from his experiment:

> that when a written passage is studies, Ss learn not only the specific content but also may acquire some general facilitative skills; namely, inspection behaviors consistent with the training objectives. (1966, p. 248)

Elementary Strategies

Further studies have focused on the investigation of specific mathemagenic activities. Typically, researchers have assessed the spontaneous and suggested use of particular learning processes for various age levels. Strategies for encoding (Neimark, Slotnick, and Ulrick, 1971; Tversky, 1973), retrieval (Ritter, Kaprove, Fitch, and Flavell, 1973), and self-testing (Flavell, Friedricks, and Hoyt, 1970; Masur, McIntyre, and Flavell, 1973) have been investigated.

In one of these studies, Bean and Rohwer (cited in Rohwer, 1974) compared the ability of subjects of the first, third, sixth, eighth and eleventh grades (n = 200) to encode lists of noun pairs. Four types of instructions were provided to the subjects prior to the learning of lists. A first type of instruction (antagonistic prompt) directed the subjects to repeat aloud a pair of words they had just learned until the appearance of the next pair. A second type of instruction (minimal prompt) asked the subjects to learn the noun pairs as best they could. A third type (explicit prompt) directed that each subject generate an event relating the two objects denoted by the nouns. A fourth type of instruction (augmented prompt) suggested contextual sentences which related the two nouns in each pair. In grades 1, 3, and 6, performance related to minimal and antagonistic prompts were equivalent, but

both effects were significantly inferior to those of explicit and augmented prompts. In grade 11, augmented, explicit and minimal prompts did not differ in their effects but entailed better performances than did the antagonistic prompt. The interesting point of this experiment was that children as young as 5 could, when verbally instructed to do so, use simple strategies for encoding. Also of interest was the finding that such strategies were spontaneously used by older children.

Allied to the same research trend, Salatas and Flavell (1975) assessed the spontaneous use of category structure as a retrieval algorithm for kindergarten, third grade, and college students. Subjects (n = 96) were asked to memorize lists of words pertaining to explicit categories (e.g. things you play with: bicycle, crayons, seesaw, whistle, sled) and then administered an indirect retrieval task which consisted of naming the objects "that can only be used outside" or "small enough to fit in this box." The retrieval strategy (retrieval algorithm) consisted in using the supplied subsumer as a cue for the retrieval of items on the list. College students generally used the strategy (n = 20) but few third grade and kindergarten students did it in a spontaneous manner (n = 3 and 1 respectively). Interestingly enough, 19 third grade students used the strategy when explicitly asked to do so.

Complex Strategies

Investigators of relatively simple strategies have mainly concentrated on the learning of tasks such as lists of words and paired associates. Few experimenters have attempted to teach students strategies for the executing of complex tasks. Crutchfield and Covington (1965) emphasized the improvement of skills and strategies in problem solving. In the first experiment, Crutchfield and Covington designed a programmed text describing detective and mystery studies. While studying, a subject had to frequently restate a problem, formulate his own questions and generate ideas to explain the mystery. Two pairs of fifth grade and one pair of sixth grade classes (n = 195) participated in the experiment. One class of each pair was administered the programmed text. After 13 lessons, both groups were administered an eight hour battery of tests on problem-solving proficiency and creative thinking. Students who were instructed in problem-solving strategies showed significantly higher scores than the control group in the number of problem-clarifying questions asked, number and quality of ideas generated, and number of problem solutions achieved.

The impressive results of this first study led to the design of a second experiment by Crutchfield (cited in Crutchfield and Covington, 1965). Two treatment conditions were added to the initial design and the number of

subjects was increased to 286. In one condition (passive exposure), subjects read the stories without being explicitly directed to solve the problems, nor to answer the questions. In the other condition (rules only), students were provided with "didactic guides to aid their thinking." Results similar to experiment 1 were obtained regarding regular instructional conditions and control groups. Although the "rules only" group surpassed the control group, this type of treatment was not as effective as the one provided in the exposure group. Crutchfield and Covington commented on the results of their studies in the following terms:

> Should these positive effects of the training program be interpreted as signifying that new problem-solving skills have been instilled (or "trained") in the child or, rather, as signifying that there has been a sensitization and activation of the use of skills which he already possesses? In the light of the relative brevity of the auto-instructional program, it is our belief that the latter interpretation is more likely. The program probably produces its effects by showing the child how to use his thought processes and by demonstrating that he can succeed in solving problems. (1965, p. 5)

More recent studies seem to confirm Crutchfield and Covington's interpretation. In one of these studies, Pellegrino and Schadler (cited in Resnick and Glaser, 1976) taught fifth graders the component routines of a general strategy for solving problems of geometry. The experiment itself involved presenting the students with a problem--determine which one of two parallelograms or one parallelogram and a rectangle is bigger. One set of students was asked to state the goal and the "plan of action" they would follow to solve the problem. Fourteen out of 16 children of this "look ahead" condition solved the problem. Of the children who were simply asked to solve the problem, only six out of the 16 were able to achieve solution. The experiment suggests that problem-solving strategies may be used by learners when they are required to verbalize the goal and the steps they intend to perform in reaching it. The study thus provides an additional example of the effects of "awareness" of learning strategies on learning effectiveness.

Learner-Controlled Instruction

While in the previous studies, investigators assessed mainly the spontaneous and suggested use of elementary strategies for the memorization of lists of numbers, words and noun pairs or use of problem-solving strategies, the studies of learner-controlled instruction have usually

evaluated the learner's ability to control a complex learning environment in the attainment of verbal information and intellectual skills. Typically, in these latter experiments, subjects were provided with sets of objectives and could determine the order in which they would study the underlying capabilities (control of instructional sequences) as the type of external stimuli needed to master these capabilities (control of instructional events). Performance and attitudes toward the course were assessed and compared with those of students provided with a fixed learning environment in which the order of presentation of objectives and instructional events had been predetermined by the designer.

Total Learner Control

In an exploratory study, Mager (1961) investigated the ability of adult learners to manage their own learning while studying electronics. The six subjects enrolled in the experiment could determine the order in which they would study the various concepts, the material they would use, and the time needed to do so. The subjects could also ask questions to instructors. Mager observed considerable discrepancy between student-generated sequence and instructor-generated sequence and a noticeable increase in motivation on the part of the subjects who had "learner control." Although interesting from a philosophical point

of view, "complete control over the curriculum" by the learner appeared of limited applicability in areas where restricted amounts of time could be allowed for mastery. It may be noted that more recent studies have employed restricted control over the instructional situation.

In a second experiment, Mager and Clark (1963) modified the previously mentioned inconvenience by supplying the learners with the objectives of the course. Six newly graduated engineering majors hired by Varian Associates were provided with learning materials and allowed to follow their own time schedule while studying theory, instruments operation, and company procedures. A decrease in training time (65%) was noticed and the graduates were judged "better equipped" for their new job than those employees who had been submitted to previous training (Mager, 1961). While this study appears to demonstrate at least a time advantage for learner-controlled instruction, some methodological problems have to be noted. Only six subjects took part in the experiment and their performances were evaluated subjectively by the experimenter. Since the subjects were newly-hired employees, they were probably highly motivated. The expression "partial learning control of sequences of instruction" seems to be more appropriate to describe this particular situation. The situation offered the learner the possibility of selecting and sequencing the objectives and

greatly helped him to encode the material, since hints on the prerequisite skills of a higher-order skill could be simply obtained by scanning the list of objectives.

Working along the same line but at the high school level (grade 9), Campbell (1964) explored the effects of allowing students control over courses of mathematics, geography and history. In mathematics (permutations, combinations and set theory) the minimum student control format was provided by a linear-programmed text. The students had to proceed through the program pages in fixed order, answering all questions and reading all the material. The students with control received the same printed pages of instruction, but differently arranged. In the latter case, for each unit, the students had at their disposal a short basic programmed text, examples and explanations, self-testing questions and a two-page outline of the entire lesson. They could use the components in any sequence they pleased. They were not required to respond to questions or to read all the material. In both groups, students could consult with the teacher at any time. Significant differences in favor of the learner-control group was observed, but in mathematics only. It is of interest to note that "coaching sessions" were offered to students in the learner-control condition. Such sessions instructed the student in how to manage his own learning.

In a second experiment, Campbell and Chapman (1967)

undertook to assess the development of "learning skills" by providing fourth and fifth grade learners (n = 216) with control over an eight month course in geography. Nine units composed the whole course. Each of the first eight units contained a list of objectives, some practice problems, and a short programmed text. Students who were given "control" could determine the order in which they would study these instructional components. Students with restricted control were presented the materials in the following order: objective, programmed segment and practice problems for each objective. After each unit a test was administered. No significant differences in performance appeared between the two methods for the first eight units. Unit nine was a "highly learner-controlled study situation" in which subjects of all groups participated. The subjects were presented with a list of objectives, practice tests, programmed geography units from the previous years, globes and encyclopedias. All subjects were told to use the materials in whatever ways they wanted. No significant difference appeared between scores of the two groups on the last unit. Some comments may appropriately be made about the methodology and conduct of these two experiments. Some of these comments expand upon those made by Campbell and Chapman. If learner-controlled instruction is conceived as an instructional method in which the learner can select and order the instructional sequences

of events, and fixed instruction as a method in which such control is restricted, the treatment conditions used by Campbell and Chapman cannot be considered adequate instances of the two methods. In the 1967 experiment particularly, both groups had at their disposal a programmed text which could be used as learning guidance. Since the programmed text was practically the only material that could provide learning guidance, it may be hypothesized that both groups read that text. If this was the case, one cannot really speak of students who had control over the conditions for their learning. In the same way, in all groups students could review the material when needed. This means that the students who were provided with fixed sequence could, at their convenience, turn the fixed-sequence condition into a learner-controlled situation. A defect of the same order appears in the experiment conducted by Newkirk (1973), to be described later.

Learner Control of Instructional Events

Other studies have attempted to evaluate separately the effects of the control of sequences of instruction (Grubb, 1968; McCann, Lahey, and Jurlock, 1973; Olivier, 1971) and of instructional events by the learner (Newkirk, 1973). Although no evidence has been found on the appropriateness of providing the learner with control over the instructional sequence, such a strategy usually appears

of little value in the context of a difficult task whose component skills are truly hierarchical (Judd, O'Neil, and Spelt, 1974; Olivier, 1971). With regard to control of instructional events, most studies have investigated the ability of learners to manage restricted and whole sets of instructional events.

In 1972, Judd, Collier and Bunderson (cited in Judd, O'Neil, and Spelt, 1974) provided college students with partial control of instructional events in a remedial course in algebra (exponents and dimensional analysis) presented via CAI. All subjects followed a predetermined instructional sequence. Two types of learner control options were considered. The first option pertained to the ability of students to determine if they required a remedial module of instruction. Before his entry into a module, a student was administered a diagnostic test, given his score, and advised of his mastery or non-mastery of the objective. The student was then free to enter the module or to proceed with the next objective. By contrast, the student under program control was automatically routed into the module if his score on the diagnostic was less than the perfect performance. A second learner control option concerned the number of practice problems to work within a module. Students who had control could determine the number of problems they wanted to work. Students under program control could proceed with the next module only

after having worked two consecutive problems. No main effects of the two factors were observed on either the exponents or the dimensional analysis parts. However, students provided with control showed better attitudes toward the course than those under program control.

In contrast with the previous experiment, R. L. Newkirk (1973) attempted to determine the relative efficiency of learner control of sets of instructional events versus a fixed presentation. Volunteers (n = 27) of high school and university level were taught introductory concepts of computer science via computer-assisted instruction. As in the previous experiment, both groups received the same sequence of instruction. Students of the learner control group could select, within each block of instruction, a definition of the concept, examples and practice problems. The students presented with predetermined order of events received the "same information" as in the learner control group but in the format of linear-programmed text. No difference was found between the two groups on the posttest but a significant difference occurred in favor of the learner-control group on a retention test administered two weeks after the experiment. Some restrictions have to be considered in evaluating results of Newkirk's experiment. A close look at the design indicates that students in the learner-control group had to succeed on a criterion test before proceeding with a new concept. Such was not

the case in the program control group. Since the mastery of prerequisite skills has been demonstrated a necessary "condition of learning" in the attainment of intellectual skills (Gagné, 1962a) the two treatment conditions may not be considered as having received the "same material." The condition "recall of prerequisites" may be involved in the learner control group, but not in the program control group.

Gagné's Theory of Learning

While investigators concentrated on the study of specific learning processes and controllable learning environments, Gagné (1970, 1974) worked to relate instructional events and learning processes. A major concern of the theorist has been to provide instructional designers with "principles" that could be used in the design of instruction (Gagné, 1962b; Gagné and Briggs, 1974). The basic idea of the theory is that human performance, although showing much diversity when observed externally, may be related to a finite set of internal "persisting states" or "capabilities," each type of capability requiring specific conditions for its attainment. Five major categories of capabilities have been identified: verbal information, intellectual skills, cognitive strategies, attitudes and motor skills (Gagné, 1972; Gagné and Briggs, 1974). In his recent works, Gagné has integrated the

findings of the information processing theorists (Atkinson, 1969; Norman, 1970) with his own theory on external and internal conditions of learning (Gagné, 1970, 1974). The resulting conceptual model relates instructional events and learning processes in such a manner that the problem of learning strategies and learner-controlled instruction can be considered in a unified context. The conceptual model used as a framework for this study is described in more detail in the following chapter.

CHAPTER III

STATEMENT OF THE PROBLEM

Two major trends have characterized the investigations of students' abilities to learn. In one case, researchers attempted to act directly on basic processes such as rehearsal, encoding, retrieval in order to improve their effectiveness. In the other case, researchers examined the effects of providing learners with control over the instructional situation and hypothesized that such an interaction would result in the attainment of generalizable learning strategies. The current study followed these two major trends but differed in certain aspects. One of the particularities of the present research was the theoretical model which was used as the framework for the research. The research relied mainly on models of the information-processing theorists and the conceptual model proposed by Gagné (1974) on the interrelationship between instructional events and learning processes.

Gagné's Model of Learning

According to Gagné (1974) learning consists in the building of various types of learning outcomes or capabilities which enable the learner to exhibit specific

behaviors. Attainment of these capabilities is the result of successive transformations of stimulus inputs stored in the sensory registers through the emission of responses by the response generator. These transformations are accomplished by the way of learning processes such as attending, encoding, retrieval, etc. Typically, the activation of a learning process is provoked by a relevant external instructional event and the attainment of a particular type of capability implies the activation of a set of critical learning processes (see Figure 1).

In this regard, the attainment of rules is mostly relevant to the instructional events: a) provide model of performance, b) stimulate recall of prerequisite concepts and rules, c) provide learning guidance, d) elicit performance, and e) provide feedback (Gagné, 1970).

The present study relies mainly on the interrelationships between instructional events and learning processes. It may be summarized in the following way. Since a given set of specific events is selected and sequenced by a designer to activate a set of relevant learning processes, it is conceivable to instruct the learner to follow these events while studying individually. In doing so, the learner will activate, on his own, the critical learning processes for the attainment of a given capability and will increase the probability of learning that capability. The learner will have acquired a learning

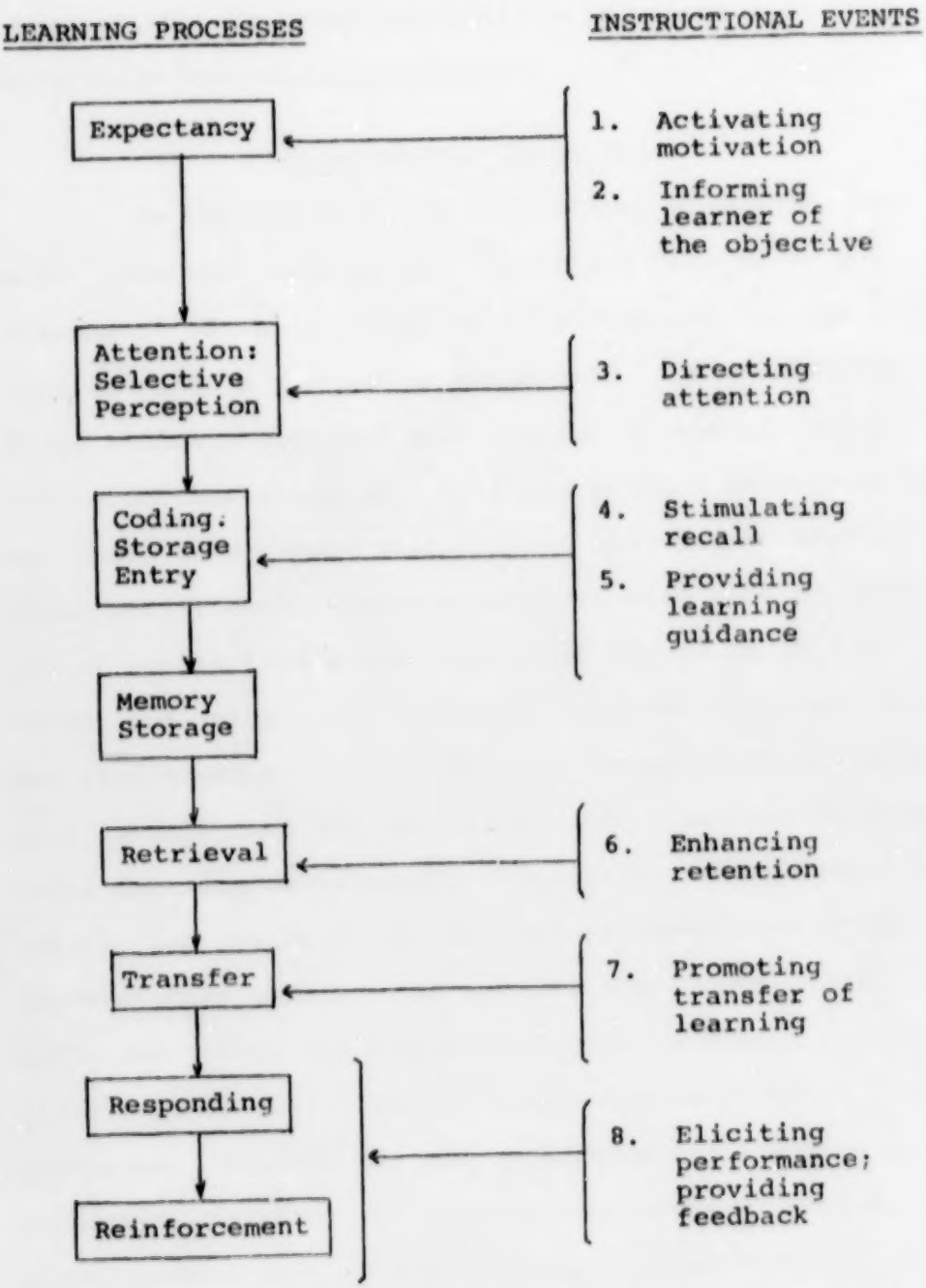


Figure 1. Relation of the learning processes to the instructional events as described by Gagné (1974).

strategy that he could use while interacting with less structured learning environments.

Experimental Questions

On the basis of the theoretical framework, two major questions were asked. The first related to the assessment of spontaneous use of strategies for the attainment of rules and would be formulated in the following way: Would students provided with control of instructional events for the attainment of rules perform as well as those who would be provided with a fixed sequence of events? In other words, would students provided with sets of instructional events from which they could choose be able to select and arrange the necessary learning processes for the attainment of rules? Previous experiments had generally investigated the ability of older learners to manage total learning environments (control of instructional sequences and instructional events) or restricted number of instructional events. The current experiment investigated the ability of younger subjects to manage sets of instructional events specifically related to basic learning processes. Besides the age difference and learning environment provided, the present experiment attempted to minimize some defects that may have jeopardized the internal validity of previous experiments by equating processes and sequences of processes that could be activated in both experimental and control groups.

A second major question which the study attempted to answer is: Can students of the elementary level be taught a complex learning strategy for the attainment of defined concepts and rules by the way of simple verbal instruction? In previous studies, subjects were instructed in simple processes for learning of lists of words, numbers, or noun pairs. The research attempted to determine if a complex strategy for the attainment of defined concepts and rules could be taught by the way of simple verbal instruction. More specifically, the following research attempted to determine if students provided with verbal instruction on the conditions of learning for the attainment of defined concepts and rules could combine the necessary underlying processes to form a learning strategy for the attainment of these capabilities.

Aside from the two major questions, the study attempted to answer the following:

1. Will students provided with fixed-optimal sequence of instruction show a higher performance than students presented with fixed-random sequence of instruction?

2. Will students provided with control of instructional events show higher retention than students using fixed sequence of instructional events?

3. Will students provided with control of instructional events take less time to complete the course than

those presented these events in fixed sequence?

4. What is the effect of mastering learning strategies on the required time to complete the course?

5. Will students provided with control of instructional events and/or instructions on a learning strategy show more positive attitudes toward the course than students using a fixed sequence of instructional events?

6. By contrast with students instructed on learning strategies, which patterns of choice will be adopted by students who were not so instructed?

7. Will students offered control of events vary their learning strategy when encountering more difficult rules and, if so, in what way?

Hypotheses

1. There will be no significant differences on within-program tests, posttest, retention test and completion time for the children provided with a fixed optimal sequence of instructional events and those who are presented with a random sequence of instructional events.

2. There will be no significant difference on within-program tests, posttest, retention test and completion time for the children provided with control over the instructional events and those who are presented with a fixed optimal sequence of instructional events.

3. There will be no significant difference on within-program tests, posttest, retention test, and completion time for the children who will receive instruction on the conditions of learning and those who will not receive such instruction.

4. There will be no significant interaction between the factor type of control and preparation for learning.

5. There will be no significant difference in attitude toward the different instructional procedures.

6. The distribution of patterns of choices will be the same for students who received instruction on learning strategy and those who were not so instructed.

7. The distribution of patterns of choice selected by students provided with instruction on learning stragegy will be the same for all skills.

8. The distribution of patterns of choice selected by students not provided with instructional strategy will be the same for all skills.

CHAPTER IV

METHOD

Design

A 2 x 3 x 4 factorial design was used in the experiment. The first variable, preparation for learning, had two conditions: (a) instruction on the conditions of learning for the attainment of rules, and (b) absence of such instruction. The second variable, type of control, had three conditions: (a) learner control of instructional events, (b) systematic control of instructional events, and (c) random presentation of instructional events. In (a), the children chose among sets of instructional events, the event or sequence of events they thought they needed for the attainment of rules. In (b), the children were provided with an optimal sequence of events as suggested by Gagne (1970). In (c), the children were presented with all the instructional events of a given rule, but in predetermined random sequence. The third variable, classes, had four conditions which consisted in 4 replications of the 2 x 3 basic design shown in Figure 2.

Subjects

Four classes of sixth grade and 15 fifth grade

Preparation for Learning	Instruction on Strategy	Type of Control: Learner Control	Type of Control: Systematic Control	Type of Control: Random Sequence
	Instruction on Strategy	GROUP A	GROUP B	GROUP C
	No Instruction	GROUP D	GROUP E	GROUP F

Figure 2. Basic research design of the experiment.

children (n = 120) from a middle class elementary school (Ecole Elementaire L'Escale, Charlesbourg, Quebec, Canada) took part in the experiment. Children were randomly assigned to one of the 24 experimental groups.

Materials

The Science of Xenograde Systems, an imaginary science, was used as the subject matter in the investigation. The science consists of a set of "laws" describing the relationships between a nucleus and its satellite. Mastery of these laws enables the learner to determine the distance between the nucleus and its satellite at any time of the system along with the constitution (number of particles) of the nucleus and satellite. The science presents strong analogies with the tasks included in scientific

topics taught in school. Since it is imaginary, the probability of encountering students already familiar with it is very low.

Some modifications were made in the Xenograde course developed by Merrill and Oliver (cited in Merrill, 1970). A hierarchy of the tasks involved in the science was devised based on Gagné's model and an instructional sequence was determined (Appendix A). For each task, a set of instructional events were designed (Appendix G). A first formative evaluation of the materials was conducted in the fall of 1975 with 10 eighth grade students of Frank Nims Junior High School in Tallahassee, Florida.

The formative evaluation helped to depict the major weaknesses of the materials. These defects were corrected and the course translated into the French language. A tryout of the materials and a simulation of the whole experiment was conducted with thirty sixth grade children of Parc Orleans Elementary School in Charlesbourg (Quebec, Canada) prior to the final experiment. The purpose of this simulation was to proceed with the formative evaluation of the instructional materials, to determine the adequacy of the various instructions given to the children, and to compute the reliabilities of the various tests which would be used in the experiment.

The materials consisted of 7.6 cm. x 10 cm. cards deposited in a 9 cm. x 12.7 cm. x 7.6 cm. plastic file

box. In the box, blue cards labeled from one through fifteen served as dividers and indicators for the different tasks. Each task comprised a set of eight cards on which were printed the instructional events. On each card a tab containing the name of the instructional event made for easy access to this event. The tabs were displayed to the students in different sequences for each one of the fifteen tasks (in an order determined at random prior to the experiment). For each task of the science, the following instructional events were available. The OBJECTIVE described the performance the students had to show after mastery of a given task. The card SKILLS TO BE REMEMBERED presented, in the form of statements of rules, the prerequisite skills of a given task to be learned. The card STATEMENT provided the children with a statement of the rule currently studied. The card DEMONSTRATION provided the children with an example of how to apply a given rule. The cards PRACTICE were used by the students to check their mastery of a rule and to be provided with feedback. The cards TESTS required to be selected by all the students before proceeding with a new task. No feedback was provided in this case. These tests were used by the experimenter to evaluate students' mastery of a completed task.

Procedure

The experiment was conducted on two consecutive regular school days. The first day, all children were

assembled in the school gymnasium and presented with a general introduction to the experiment. Appendix B presents the text of the presentation made by the experimenter (the writer) on that occasion. Children were then assigned to the room in which they would work on the first day of the experiment. Half of the children were assembled in the school library to receive instruction on the learning strategy. The children worked under the supervision of the experimenter and one assistant. Instruction on the learning strategy was made by means of a programmed text (see Appendix C) and team work. First, the experimenter and his assistant distributed the instructional materials and the children worked individually for one hour and thirty minutes to two hours (including 20 minutes for regular recreation time). After completion of his reading of the programmed text, the student raised his hand and the instructor scored his answers to the three questions which appeared at the end of the text (see Appendix C). If the child had correctly answered the three questions, his name was recorded as a possible tutor.

During that time, the other sixty children worked with a programmed text (Thiagaragan, 1971) on how to build magic squares, under the supervision of two instructors. As in the learning strategy group, children who had completed reading of the programmed text were engaged in independent study of regular school material.

After lunch time, children of the learning strategy group were divided into groups of 5 or 6 tutees working under the direction of a tutor. The work of the tutor consisted of conducting a revision of the learning strategy using the questions at the end of each section of the programmed text. Once a tutor considered that his tutees had mastered the materials, he raised his hand and one instructor checked with the tutees by asking questions from the end of the text. Once all the teams mastered the materials, a posttest (Appendix D) was administered to tutors and tutees. The tests were scored by the experimentor during recreation time. Twenty-seven students out of 59 (one absence was recorded) reached the criterion (4 over 5). The last hour of the day was used by the experimenter and his assistant to review the materials with the children who had failed to reach the criterion. The review consisted of a summary of the content of each section of the programmed text. The same version of the posttest previously mentioned (Appendix D), was administered and scored by the experimenter and the instructor. Nineteen students out of 32 reached the criterion on that occasion. This made a total of 46 out of 59 students, or 77.9% who had reached the criterion.

The next morning, children were assigned to four adjacent classrooms (4 replication of the original 2 x 3 factorial design). Four teachers of grade 6 who had pre-

viously been trained (2 sessions of 1 hour) served as instructors in each classroom. A written introduction to the science of Xenograde systems was distributed by the instructor to each of the children (Appendix E).

Following the reading of this introduction, a text on the prerequisite skills of the Xenograde science was distributed (Appendix F). After completion of the test, answers to the questions were provided to the children. The mean of the test on prerequisites was 84.5%. When a student missed a question, the instructor provided him with an explanation and gave him the right answer. Children were then provided with the instructional materials (Appendix G) and general instructions on the procedure of how to use it (Appendix H). After individual reading of these instructions, specific instructions on each experimental condition were distributed (Appendix I). Children were told by the instructor to wait until the signal before starting their study of Task 1. Once all children had completed their reading of the instructions, the time was recorded by the instructor and the children started their study of the Xenograde science. The study of the science was interrupted by recreation and lunch time (20 minutes for recreation in the middle of the morning and afternoon; two hours for lunch time). After completion of their study, the children recorded the exact time on the last card of Task 15 and brought the

file box to the instructor. The child was then administered a posttest and an attitude test (Appendix J, K). Two weeks later, a parallel form of the posttest was administered to all children and a debriefing session was held with the children who took part in the epxeriment.

Evaluation Instruments

Assessment of the Learning Strategy

Although the assessment of the learning strategy was going to be realized with the learning of the Xenograde science, indirect assessment was done on the first day of the experiment. The children were presented with five written questions (Appendix D). Each question contained four paragraphs which presented, in a random sequence, the instructional events for the learning of rules. For each question, the child had to supply the order in which the paragraphs (instructional events) had to be learned. A test-retest reliability coefficient of .81 was obtained correlating scores of the 30 children who participated in the formative evaluation of the materials.

Performance Measures

Test items used in performance assessment (within-program tests, posttest, retention test) were constructed from a pool of items measuring each of the competencies identified in the learning hierarchy. Two items for each

competency were selected at random for inclusion in the within-program tests, posttest, and retention test. Items required students to predict future states of a Xenograde system by making entries in a Xenograde table. The items of the posttest and retention test were presented in random order and no time limit was imposed for completion of these tests. The retention test was administered two weeks after completion of the course. The reliabilities of the within-program tests, posttest and retention test were estimated by using the KR-20 formula and are presented in Table 1.

Table 1

Reliabilities of Within-Program Tests, Posttest, and Retention Test

	Within-program tests	Posttest	Retention test
Reliability (KR-20)	.85	.82	.72

Time Measures

The time at which the children began their study in each classroom was noted by the instructor. Once a child had completed the study of the Xenograde science he

recorded the exact time (hour, minute) he had completed the experiment on the last card of Task 15. The total time of study for each child was obtained by subtracting the time when the course was initiated from the time it was completed (less 40 minutes for recreation and two hours for lunch).

Attitude Measures

The principal instrument used to assess the children's attitudes was a modification of a similar scale for computer-assisted instruction developed by Brown (1966). The test is presented in Appendix K. A reliability coefficient of .78 was obtained by using the split-half method.

CHAPTER V

RESULTS

Five dependent variables were examined in this study: within-program test scores, posttest scores, retention test scores, attitude test scores, and time required to complete the course.

A 2 x 3 x 4 (Preparation for learning x Type of control x Classes) ANOVA was performed for each dependent variable. Preparation for learning and type of control were considered fixed factors and classes was considered a random factor. A summary of these analyses and relevant descriptive statistics are given in the first part of this section. An analysis of the patterns of choice adopted by the children who were in control is provided in the second part.

Within-Program Performance and Time

Tables 2 and 3 present the means and standard deviations for within-program performance and time required to complete the study of Xenograde science. These tables show that slight differences exist among the various means but neither the major factors nor their interactions reach significance. Tables 4 and 5 present the ANOVA summary for these variables.

Table 2

Within-Program Tests Group Means and Standard Deviations as a Function of Preparation for Learning and Type of Control

Preparation for Learning	Type of Control					
	Learner Control		Systematic Control		Random Sequence	
	M	SD	M	SD	M	SD
Instruction on Strategy	18.60	5.99	17.85	6.18	19.70	5.36
No Instruction	19.30	6.67	22.40	4.85	19.50	5.86

Note: Maximum score = 30

Table 3

Total Time Group Means and Standard Deviations as a Function of Preparation for Learning and Type of Control

Preparation for Learning	Type of Control					
	Learner Control		Systematic Control		Random Sequence	
	M	SD	M	SD	M	SD
Instruction on Strategy	101.55	23.44	107.55	34.32	99.55	35.50
No Instruction	102.35	28.89	97.20	37.91	95.90	26.49

Note: Time is in minutes

Table 4

Analysis of Variance Summary for Within-Program Performance Scores as a Function of Preparation for Learning and Type of Control

SOURCE	df	SS	MS	F
Preparation for Learning (A)	1	85.00	85.00	2.29
Type of Control (B)	2	27.71	13.85	.77
Classes (C)	3	93.49	31.17	.87
A X B	2	127.32	63.65	2.30
A X C	3	111.36	37.13	1.04
B X C	6	107.69	17.95	.50
A X B X C	6	166.01	27.65	.77
Error	96	3423.00	35.65	
Total	119	4141.59		

Note: See Appendix L for the expected mean squares and error terms used in the analysis.

Table 5

Analysis of Variance Summary for Completion Time as a Function of Preparation for Learning and Type of Control

SOURCE	df	SS	MS	F
Preparation for Learning (A)	1	580.83	580.83	.39
Type of Control (B)	2	528.75	264.37	.23
Classes (C)	3	339.26	113.08	.12
A X B	2	630.02	315.01	.24
A X C	3	4406.44	1468.81	1.50
B X C	6	6903.99	1150.66	1.18
A X B X C	6	7801.91	1300.32	1.33
Error	96	93836.80	977.47	
Total	119	115038.00		

Note: See Appendix L for the expected means squares and error terms used in the analysis.

Although no significant differences were found among the reported means, it may be of interest to note that some common trends exist for these two dependent variables. Figures 3 and 4 show that little difference in performance appear for the children who were in control of their learning, whether they had preparation for learning or not. This situation also prevails for the treatment condition random sequence of events. A larger dis-

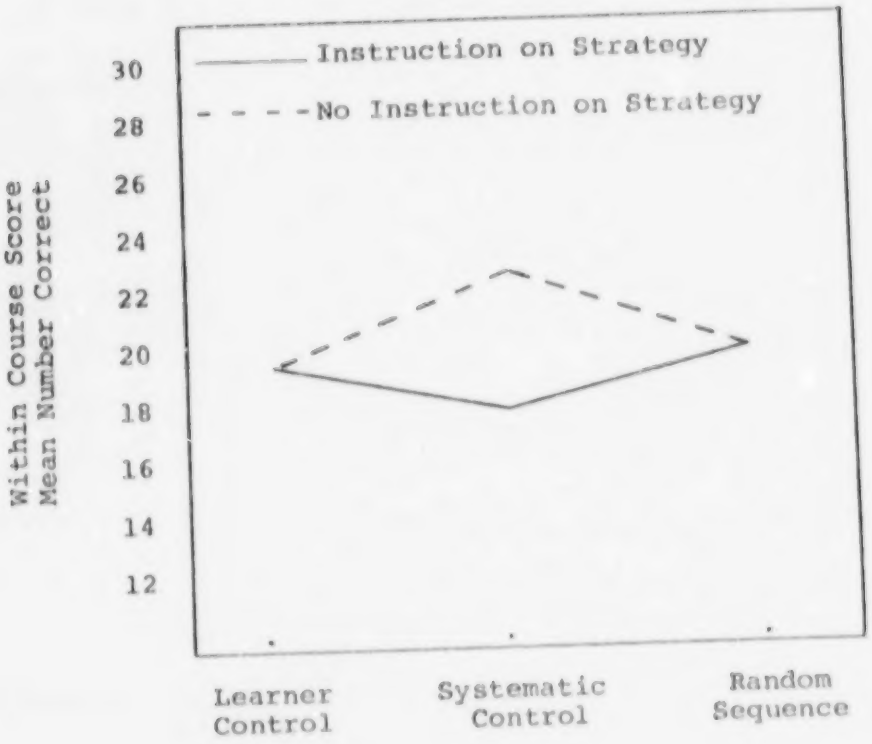


Figure 3. Mean number of correct responses in within-program tests as a function of preparation for learning and type of control.

crepancy, however, exists among the scores of the children who were under systematic control, whether they had preparation for learning or not. This same trend will appear in the case of the variables posttest and retention performance.

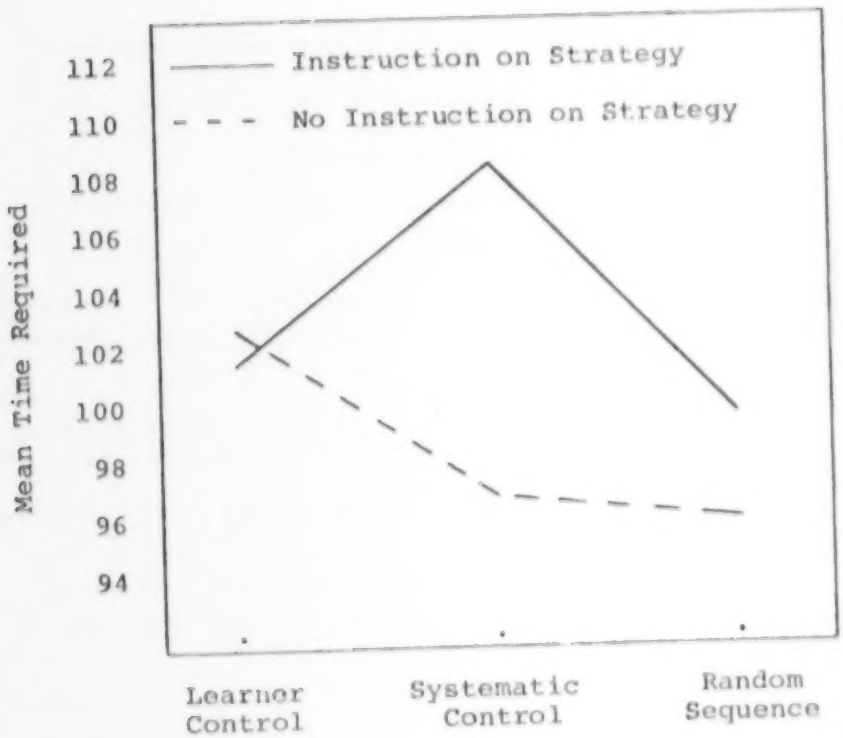


Figure 4. Mean time required to complete the course as a function of preparation for learning and type of control.

Posttest and Retention Test Performance

Table 6 presents the means and standard deviations for the number of correct responses at the posttest. Neither the main effects nor the interaction were statistically significant.

Table 6

Posttest Group Means and Standard Deviations as a Function of Preparation for Learning and Type of Control

Preparation for Learning	Type of Control					
	Learner Control		Systematic Control		Random Sequence	
	M	SD	M	SD	M	SD
Instruction on Strategy	15.50	6.07	12.75	6.43	14.75	5.14
No Instruction	15.55	5.63	16.90	6.30	15.90	6.71

Note: Maximum score = 30

Table 7 presents the ANOVA summary for this variable. Although no significant differences were obtained for this variable, the same trend as noted for the variables within-program performance and time required to learn may be depicted in Figure 5.

Table 7

Analysis of Variance Summary for Posttest Peformance Scores as a Function of Preparation for Learning and Type of Control

SOURCE	df	SS	MS	F
Preparation for Learning (A)	1	95.41	95.41	2.21
Type of Control (B)	2	10.40	5.20	.55
Classes (C)	3	175.62	58.54	1.52
A X B	2	90.07	45.03	1.57
A X C	3	129.09	43.03	1.12
B X C	6	56.60	9.43	.25
A X B X C	6	171.30	28.55	.74
Error	96	3674.40	38.27	
Total	119	4402.89		

Note: See Appendix L for expected mean squares and error terms used in the analysis.

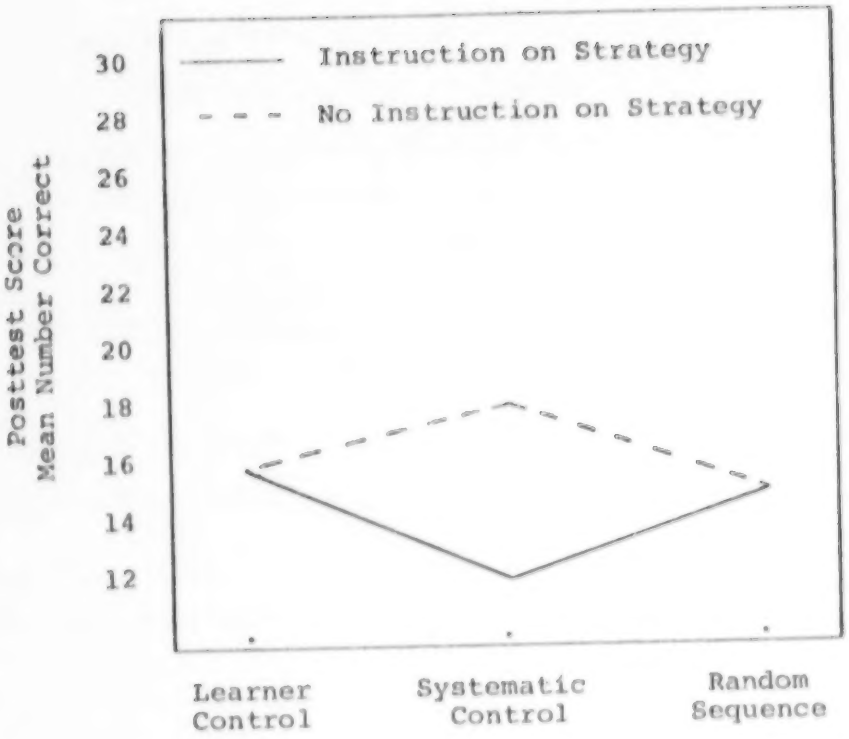


Figure 5. Mean number of correct responses in posttest as a function of preparation for learning and type of control.

Table 8 presents the means and standard deviations for the number of correct responses on the retention test. A significant main effect was obtained for preparation for learning and the interaction of preparation for learning and type of control was significant.

Table 8

Retention Test Group Means and Standard Deviations as a Function of Preparation for Learning and Type of Control

Preparation for Learning	Type of Control					
	Learner Control		Systematic Control		Random Sequence	
	M	SD	M	SD	M	SD
Instruction on Strategy	14.05	5.18	11.60	5.00	13.55	4.71
No Instruction	14.35	3.66	16.45	4.79	13.40	6.02

Note: Maximum score = 30.

Table 9 presents the ANOVA summary. Analysis of variance for the simple effects of the types of control for each type of preparation is summarized in Table 10. The analysis of variance for the simple effects of the preparation for learning for each type of control is summarized in Table 11.

The interaction means were compared with the Newman-Keuls test and showed that: (a) children who had no instruction on strategy and were presented with a systematic

Table 9

Analysis of Variance Summary for Retention Performance Scores as a Function of Preparation for Learning and Type of Control

SOURCE	df	SS	MS	F
Preparation for Learning (A)	1	83.33	83.33	757.54***
Type of Control (B)	2	11.45	5.72	1.05
Classes (C)	3	22.87	7.62	.31
A X B	2	153.02	76.51	8.98*
A X C	3	.33	.11	.00
B X C	6	32.28	5.38	.22
A X B X C	6	51.12	8.52	.35
Error	96	2360.40	24.59	
Total	119	2714.80		

Note: See Appendix L for expected mean squares and error terms used in the analysis.

* $p<.05$
*** $p<.001$

Table 10

Analysis of Variance for Simple Effects of the Factor Type of Control for Retention Performance Scores

Source	df	SS	MS	F
B for A_1	2	97.44	48.72	9.06*
B for A_2	2	67.03	33.51	6.22*
B x C	6	32.28	5.38	

*$p<.05$

Table 11

Analysis of Variance for Simple Effects of the Factor Preparation for Learning for Retention Performance Scores

Source	df	SS	MS	F
A for B_1	1	.90	.90	8.18
A for B_2	1	235.22	235.22	2138.36***
A for B_3	1	.22	.22	2.00
A x C	3	.33	.11	

Note. See B. J. Winer, Statistical principles in experimental design (2nd ed.; New York: McGraw-Hill Book Company, 1971), pp. 441, 461.

***$p<.001$

order (optimal sequence) scored significantly higher than the children who had control over their learning or who had the events presented in a random sequence, and that (b) children who had instruction on learning strategy and were presented with a systematic order scored significantly lower than children who had control and those who received the events in a random sequence. The same trends as observed for the various within-program performance, posttest scores, and time may be depicted for retention performance (Figures 3, 4, 5, 6).

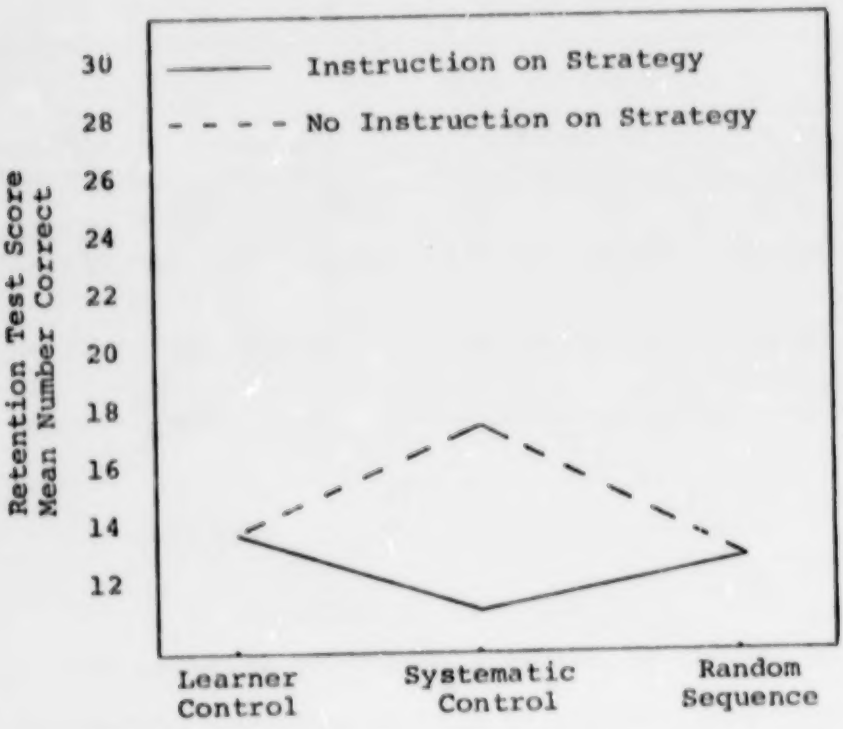


Figure 6. Mean number of correct responses in retention test as a function of preparation for learning and type of control.

Table 12 presents the means and standard deviations of the scores on the attitude test. There were no significant effects of the factors preparation for learning and type of control nor of the interaction of these factors. Table 13 presents the analysis of variance summary for this variable.

Table 12

Attitude Test Group Means and Standard Deviations as a Function of Preparation for Learning and Type of Control

Preparation for Learning	Type of Control					
	Learner Control		Systematic Control		Random Sequence	
	M	SD	M	SD	M	SD
Instruction on Strategy	133.10	14.83	121.85	18.89	129.25	16.04
No Instruction	133.60	14.66	130.70	17.10	135.05	16.37

Analysis of Patterns

The patterns of choice selected by the children who were in control were stored into 15 x 4 matrices (Appendix M). Each row of a matrix contained a set of four characters (one character per event; O = objective, P = skills to

Table 13

Analysis of Variance Summary for Attitude Test Scores as a Function of Preparation for Learning and Type of Control

SOURCE	df	SS	MS	F
Preparation for Learning (A)	1	765.08	765.08	1.73
Type of Control (B)	2	1146.82	573.41	1.32
Replications (C)	3	237.56	79.19	.32
A X B	2	707.05	353.52	.88
A X C	3	1324.89	441.63	1.79
B X C	6	2613.58	435.60	1.76
A X B X C	6	2415.22	402.54	1.63
Error	96	23668.80	246.55	
Total	119	32879.00		

Note: See Appendix L for expected mean squares and error terms used in the analysis.

be remembered, X = demonstration, R = practice). The event statement, which duplicated in some way the event demonstration, was removed from the list of events under investigation. There were 15 rows in each matrix (one row for each skill). A matrix "X" of the sequence of cards as they appeared in the file boxes and a matrix "Y" of the optimal pattern (OPXR) were built.

In a first step, matrices of patterns recorded for all children were compared to matrices "X" and "Y" (the APL system was used to do the comparisons and further analysis). These comparisons allowed the determining to which extent the children used the learner control option and the optimal strategy.

In group A (learner control option with preparation for learning), 9 children out of 19 used the control option for 0 to 5 skills, 6 children used it for 6 to 10 skills, and 4 children used it for more than 10 skills (one absence was recorded). Regarding the optimal strategy, 2 children used it once, 1 child used it twice, 1 child used it four times and one child used it twelve times.

In group B (learner control option without preparation for learning), 14 children out of 19 used the control option for 0 to 5 skills (among these 10 did not use it at all), 1 child used it for 8 skills, and 4 children used it for more than 10 skills (one matrix of patterns

was ignored to counterbalance the effect of one absence in group A). No child of group B used the optimal strategy.

The probability of selecting by chance the optimal strategy was computed using the binomial formula. The probability of selecting one time or more the optimal strategy is $p<.02$. Five children out of 19 used the optimal strategy for one time or more in group A and no children used it in group B. The data indicate that the children who received preparation for learning had a significant tendency to select the optimal strategy.

In a second step, the specific patterns selected by the children of both learner control groups were examined (see Lahey and Crawford, 1976). A tree of all possible patterns was designed and a 24 x 4 matrix of characters was built with possible patterns as rows (Appendix N). Since a few children had ignored one or more events in their study (two children of group A and two children of group B ignored some events for more than five skills), the possible patterns were obtained with the arrangement of four characters (OPXR) taken four at a time ($A\ \frac{4}{4} = 4\ !\ = 24$). The patterns selected by each child at the level of each skill was compared to each row of the matrix of possible patterns. Matrices of the frequencies of utilization of the various patterns at the level of each skill for all children of group A and all children of group B were designed (Appendix O).

A low frequency in the use of patterns different from the one suggested by the sequence of cards in a file box made inappropriate statistical comparisons of the distributions of patterns for different skills (Gibbons, 1976). A summation of rows in the matrices of Appendix O allowed for determination of frequency of patterns used in groups A and B. Entries which were less than 5 for a possible pattern in both groups were removed and entries 1 and 7 were combined (Gibbons, 1976). Table 14 presents the distribution of patterns used in the statistical analysis.

Table 14

Selection of Particular Patterns

in Groups A and B

Patterns	Group A	Group B
OPXR	35	7
POXR		
XOPR	4	5
XPOR	6	8
RPXO	6	1
RXOP	4	13

A chi-square goodness of fit test indicated a significant difference between the two distributions ($\underline{X}^2 = 23.7$, $\underline{df} = 4$, $\underline{p} < .001$). Analysis of Table 14 indicates that children of group A selected the patterns OPXR and POXR (the optimal strategy and a neighbour one) 35 times while these patterns were selected 7 times by the children of group B. Pattern RPXO, in which the first and last steps of the optimal strategy have been inverted, is also of interest. To conclude, it may be observed that children of both groups were rather conservative in their use of the optimal strategy. The strategies OPXR and POXR have been used only 35 times in group A while they could have been selected 285 times (19 children x 15 patterns OPXR and/or POXR). Despite the low use of the optimal strategy by the children who had preparation for learning, results show that children of this condition were more interested in selecting it than children who had no preparation for learning.

CHAPTER VI

DISCUSSION AND IMPLICATIONS

The results of the experiment indicate that a systematic execution of the learning processes is an important factor in the learning of defined concepts and rules. The data show that the children who were presented with an optimal sequence without instruction especially preparing them for learning scored significantly higher than any other experimental group. The superiority of an optimal presentation of instructional events over a learner selection of such events is also indicated.

Results of the study did not support the proposition that a brief period of instruction on the conditions of learning would result in higher performance. Analysis of the patterns of choice of the children who were in control and who did not receive instruction on the conditions of learning suggests a virtual absence of learning strategies at this age level. Analysis of the patterns of choice selected by the children who were in control and who also received instruction on the conditions of learning suggests a higher tendency to use the optimal strategy than for the children who were not taught such a strategy.

Little use of the learner control option made inappropriate a comparison of the attitudes toward the various instructional procedures and also the analyses suggested by hypotheses 7 and 8. A detailed discussion of these results is presented in the following section.

Optimal vs. Random Sequence, No Preparation for Learning

The one-to-one correspondence between instructional events and learning processes described by Gagné (1974) may be verified by comparison of optimal versus random presentation of instructional events. In Gagné's framework, an optimal sequence of events activates a set of learning processes in an order such that the output of a given process serves as the input for the next learning process. An optimal sequence of this sort should facilitate learning and reduce learning time. In the present study, a significant difference appeared on the retention test in favor of the optimal sequence group over the random sequence group. Common trends of this variable with the scores on the within-course tests and posttest were also observed. These data are in conformity with the information-processing model, and with Gagné's point of view on the hypothesized structures, processes, and sequences of learning processes derived from the information-processing model (Gagné, 1974).

Some questions may be raised, however, regarding the scores of the children who were presented with random sequences of events. Results from these children indicate that even a random presentation of events produced learning. Two factors may have been responsible for this finding. A first factor relates to the hypothesized structures of the information-processing model. Bower (1975) describes the role of the working memory as the physical support for plans and executive processes which "call routines at the next lower level and keep track of where these sub-routines are to return their results" (p. 32). In a first step, the instructional events of a given skill, although read in a random sequence, may have been stored in the working memory. In a second step, these events may have been reorganized in such a way that the corresponding learning processes are executed in sequences or sub-sequences compatible with an optimal sequence proposed by Gagne.

A second factor which may have produced learning through a random presentation of instructional events relates to the instructional materials themselves. Typically, the function of an event is to activate a specific learning process. Analysis of the events employed with the instructional materials suggests that more than one function may have been performed by a single event. For

example, besides activating the forming of expectancies, the words of the statement of an objective may have activated the recall of prerequisite skills, accomplished some learning guidance and, entailed practice. Similar phenomena may have occurred with the instructional events statement, demonstration and practice. In this context, several of the patterns suggested by the file cards, although randomized, may have entailed a near-optimal execution of learning processes.

Learner Control vs. Systematic Control, No Preparation for Learning

Rohwer and Bean (cited in Rohwer, 1974) observed that students of grade 11 spontaneously used strategies for the retrieval of noun pairs. This research examined the spontaneous use of learning strategies for the attainment of rules by sixth graders. Lower scores were obtained on the retention test for the children who were in control, compared to those who received an optimal sequence. Such trends were also observed for the variable measured by the within-course tests, the posttest, the retention test, and completion time. Examination of the patterns selected by the children who were in control provides an explanation of their low scores and throws light upon data gathered in previous learner control studies.

The patterns of events actually selected by the

children who were in control suggests a strong tendency to ignore other patterns than those proposed by the physical arrangement (randomized) of the cards in a file box. Only four children of this treatment condition used the learner-control option more than ten times. Selection of random sequences of events by these children implies a lack of strategies for the attainment of rules. Interestingly enough, however, in a debriefing session held two weeks following the experiment, several children underlined the importance of every event for optimal learning (most children took all the cards of a given task). Although such a decision suggests an understanding of the importance of every instructional event by the children, it nevertheless reveals an absence of understanding of the order in which the underlying learning processes related to these events need to be executed, according to theory.

Results of the current research contrast with those on learner-controlled instruction obtained by Campbell and Chapman (1967) and Judd, et al. (1974). The non-significant difference in performance for children of the learner control and system control options observed in these studies may be related to the methods used for delivering of instruction. In a discussion of their 1967 experiment, Campbell and Chapman stated that the equivalence of methods may be due to the fact that "conditions common to the two treatments were more important than the

conditions which differentiated them" (p. 129). In fact, in the Campbell and Chapman experiment, the instructional materials were presented in optimal sequences in both learner control and system control groups. The main difference may be attributed to the fact that children of the former condition could determine the order in which they would study the instructional materials. In such a situation, if the children selected the materials in the order physically presented (as they did in the current experiment), the study amounts to a comparison of two nearly identical treatment conditions. The current study precluded such difficulties by offering a random sequence of events as an alternative to the learner-control option.

Learner Control, With and Without Preparation for Learning

Rohwer and Bean (cited in Rohwer, 1974) observed that children as young as five could be taught strategies for the retrieval of noun pairs. In the present study, the expectation that children of the elementary level could be taught a complex strategy for the attainment of rules only partially materialized within the limited time permitted. No significant differences were found between scores of the two groups who were in control, whether or not they had received preparation for learning. Examination of the patterns of choice of the children who re-

ceived instruction revealed a limited tendency to use the optimal strategy. Three factors may explain a low utilization of the learning strategy by the children who were explicitly taught such a strategy. First, the strategy may have been acquired but not retrieved at the time of learning. It is of importance to notice that no clues on the possibility of using such a strategy were given in the directives of the experiment, nor in the instructional materials. Specific clues for the using of the learning strategy would have probably increased its use. Second, an incomplete strategy may have been engendered for optimal management of instructional events. Possibly because of limited familiarity and practice, instruction on strategies plus learner control under these conditions did not significantly exceed a random sequence condition. It seems possible that a more extensive teaching of the learning strategy would have entailed a higher use, and consequently produced higher performance. Still a third possibility is that no strategy may have been acquired during preparation for learning. Results obtained in previous studies by Crutchfield and Covington (cited in Crutchfield and Covington, 1965) together with the analysis of patterns selected in the current experiment, seem to favor the first two of these explanations.

Systematic Control, With and Without Preparation for Learning

Unexpected results were obtained by the children who were prepared for learning and also presented with an optimal sequence of events. Scores of these children on the retention test, were significantly lower than the scores obtained in any other of the experimental groups. The mean of this experimental group on the retention test is 12% lower than the mean of children who were presented with an optimal sequence without receiving any preparation for learning. Such a phenomenon may be a consequence of metacognition (Flavell, 1976). For Flavell, "metacognition refers to one's knowledge concerning one's own cognitive processes and products or anything related to them, e.g. the learning-relevant properties of information or data" (p. 232). Knowledge of the learning strategy by the children who received preparation for learning may have entailed metacognition activities. Interaction with a given instructional event for children of this treatment condition could have activated classifying and ordering activities (the child attempting to identify the card's goals, skills to be remembered, etc. and verifying whether the optimal order was respected in a given sequence). Such metacognitive activities may have detracted from adequate concentration on the learning of a capa-

bility itself and consequently resulted in lower performance for the children of this treatment condition. An increase in familiarity and practice with the learning strategy would probably have decreased the interfering effect of metacognition phenomena.

Implications for Future Researches

The current study attempted to investigate Gagne's theoretical ideas on the interrelationships between learning processes and instructional events, in the course of examining the spontaneous and directed use of learning strategies for the attainment of defined concepts and rules. The following are suggestions for future research which could be conducted in a similar framework. These studies have been regrouped under headings which suggest necessary and complementary steps for the development of strategies pertaining to specific outcome domains of verbal information, intellectual skills, motor skills and attitudes. These steps relate to the describing, validating and teaching of learning strategies.

Describing Learning Strategies

The design and development of instruction for verbal information, intellectual skills, motor skills and attitudes rely heavily on written and/or oral descriptions of the capabilities which are going to be taught.

These descriptions detail the target capability and facilitate communication between the subject-matter specialist and the instructional designer. This imperative has not always been considered seriously by the proponents of the teaching of learning strategies (see Graubard, 1972).

The establishment of the conditions of learning in terms of learning processes provides a valuable tool for the describing of specific learning strategies. In Gagne's framework, a learning strategy or executive procedure may be defined as an ordered set of learning processes which have to be executed if the attainment of a given capability is to occur. The first step of the description of a learning strategy should then consist in the listing of the learning processes which will constitute the major steps of the executive. On that matter, investigation of adequate techniques for the illustrating of the executive procedure seems to be necessary.

In computer sciences, written programs and flowcharts have been fundamental tools for the describing of procedures and executive routines. Investigators of cognitive strategies applicable to thinking and problem solving have successfully used such techniques (see Newell and Simon, 1972). Similar efforts should be made for the describing of cognitive strategies applicable to learning.

Validating Learning Strategies

Once hypothetical learning strategies have been described, data on their effectiveness have to be gathered. Performance and completion time seem valuable indicators of the mastery of a given strategy. Opportunity for using the ratio of performance and time (speeded tests) as an indirect measure of effectiveness for a strategy should also be examined.

Comparison of experimental and control groups as a way to assess the effectiveness of a given strategy presents some inconveniences, since a finding of no increase in performance on the part of the experimental group may either be attributed to the non-effectiveness of either the strategy or the delivering of instruction. Such a defect may be avoided by using designs similar to the one used in the current experiment, in which an optimal execution of learning processes was compared to a random execution. In this context, it is suggested that the evaluating of a learning strategy should be conducted in a two-step process. First, comparison should be made of random and optimal executions of learning processes. In the eventuality of a higher performance for the optimal sequence, comparison would then be made of results from groups of subjects taught and not taught the learning strategy.

Conditions of Learning

Additional studies should be conducted to investigate the conditions of learning common to learning strategies for different learning domains. The present study appears to suggest that the factors of practice and time may well be critical to the attainment of learning strategies. Similar conclusions also seem suggested in the studies by Crutchfield and Covington (cited in Crutchfield and Covington, 1965) and Pellegrino and Schadler (cited in Resnick and Glaser, 1976). Studies using instructional materials and design similar to those of the current experiment would be expected to yield valuable data on this subject.

As a first step, the effect of practice should be examined. It has to be remembered that little practice was provided to the children on the first day of the current experiment. An experiment could be designed using various levels of practice for the factor of preparation for learning. As a suggestion, the levels of practice contrasted could be zero and five or more tasks of the Xenograde science.

Along the same line, the effects of delayed reviews on performance should be further examined. Similar instructional materials (Xenograde science) could be utilized, but materials used in the reviews should be developed.

Another variation in the factor "preparation for learning" would relate to the type of directives given to the children prior to the study of a given subject matter. In this context, it would be interesting to compare the performance of children who would be told explicitly to use the strategy, with those who would not be told to do so. On that matter, studies combining Rothkopf's designs for the learning of prose materials and Gagné's theory on the conditions of learning would present a study of great interest.

Another interesting avenue to consider would be the assessment of the spontaneous use of the learning strategy taught in the current experiment with students of different school levels. Such studies have been conducted in previous investigations of single learning processes (Salatas and Flavell, 1975). The instructional materials used in the current experiment seem appropriate to the conduct of such studies.

The use of instructional materials pertaining to various subject-matter fields should be encouraged in the conduct of these studies. Interestingly enough, several instructional materials based on Gagné's theory have already been designed, and could easily be modified for use in studies on learning strategies.

APPENDIXES

APPENDIX		Page
A.	Hierarchy of Skills	70
B.	Introduction to the First Part of the Experiment.	74
C.	Programmed Text of the Learning Strategy. . .	76
D.	Learning Strategy Posttest.	92
E.	Introduction to the Second Part of the Experiment.	96
F.	Test of Prerequisite Skills	100
G.	Xenograde Science Instructional Materials . .	104
H.	Description of the Instructional Materials. .	135
I.	Instruction Booklets.	139
J.	Posttest.	146
K.	Attitude Test	158
L.	Expectation of Mean Squares and F-Ratio . . .	164
M.	Patterns Selected by the Children	166
N.	Matrix of Possible Patterns	169
O.	Matrices of Frequencies	171

APPENDIX A

HIERARCHY OF SKILLS

HIERARCHY OF SKILLS

Note. See corresponding objectives on next page. * = prerequisite skills.

Objectives

1. Given a graphical reproduction of a Xenograde system, you will supply the ACN (Alphons Count of the Nucleus) of the system.

2. Given a graphical reproduction of a Xenograde system, you will supply the ACS (Alphons Count of the Satellite) of the system.

3. Given a set of descriptions, you will point at the description of a Force Field.

4. Given the table of the evolution of a Xenograde system, you will supply the time of an event.

5. Given the table of the evolution of a Xenograde system, you will supply the state of the Xenograde system for a given time.

6. Given the table of the evolution of a Xenograde system, you will supply the blip-time.

7. Given the values of ACS, the nucleus-satellite distance at a given time, and a FF of value 1, you will predict the next nucleus satellite distance.

8. Given the value of FF, the nucleus-satellite distance at a given time, and an ACS of value 1, you will predict the next nucleus-satellite distance.

9. Given the values of FF, ACS, and the nucleus-satellite distance at a given time, you will predict the next nucleus-satellite distance.

10. Given the values of ACN and ACS at a given time, you will predict the values of ACN and ACS at the next time.

11. Given the values of ACN and ACS before a blip, you will predict the values of ACN and ACS after the blip (for an even blip time).

12. Given the values of ACN and ACS before a blip, you will predict the values of ACN and ACS after the blip (for an odd blip time).

13. Given the values of FF and ACS, you will predict the nucleus-satellite distance after a collision.

14. Given an NAN of 0 and an even blip-time, you will predict the values of ACN and ACS after the blip.

15. You will predict the maximum nucleus-satellite distance after a collision.

Prerequisite Objectives

1*. Given a graphical reproduction of a Xenograde system, you will identify the nucleus-satellite distance.

2*. Given a set of descriptions, you will point at the description of the table of a Xenograde system.

3*. Given a graphical reproduction of a Xenograde system, you will identify the alphons of the system.

4*. Given a graphical reproduction of a Xenograde system, you will identify the nucleus of the system.

5*. Given a graphical reproduction of a Xenograde system, you will identify the satellite of the system.

6*. Given a list of numbers, you will identify the even numbers.

7*. Given a list of numbers, you will identify the odd numbers.

APPENDIX B

INTRODUCTION TO THE FIRST PART OF THE EXPERIMENT

INTRODUCTION TO THE FIRST PART OF THE EXPERIMENT

You will take part today in an experiment in learning psychology. You will be asked to learn several new concepts. The results of this research will make it possible for us to understand how you and your friends learn, and will probably result in more effective ways to teach and learn. By taking part in this experiment you will help your friends, your teachers and yourself. That is why we ask you to give the best of your attention to the execution of the different tasks that will be presented to you in the coming two days. You will now ask your teacher where you are going to work for this first part of the experiment.

APPENDIX C

PROGRAMMED TEXT OF THE LEARNING STRATEGY

PROGRAMMED TEXT OF THE LEARNING STRATEGY

The goal of this short text is to teach you how to learn. In the following pages you will find a description of four steps which are important to follow when you want to learn something new. Read this text carefully, answer the questions which are presented at the end of each paragraph and check your answers with those ones presented at the end of the text. When you have finished studying this text you will be tested on what you learned.

LEARNING TO LEARN

When an engineer builds a tower, a bridge or a building he executes certain steps. First, he establishes a goal (to build a tower, to build the first floor, the second floor, etc.). Second, he verifies if he has the materials which are necessary to reach his goal (steel bars, binders, nails, etc.). Third, he assembles those materials according to an established plan. Fourth, he verifies if he reached the goal he established.

When you are about to learn something, you must follow steps similar to the ones the engineer executed to build the tower. The four steps you have to execute are described in detail in the following pages. Learn those steps and you will be able to learn more easily afterwards.

STEP 1: THINK OF WHAT YOU WILL BE ABLE TO DO AFTER HAVING LEARNED

Every day you do a lot of things: you go to school, you visit with friends, you play ball and so on. Before you do these things you think, just as the engineer... "now I am going to do this, then I will do that, and so on." You establish goals and then try to reach them. Have you ever thought about what would happen if, having decided to visit a friend, you forgot your goal (visit your friend)? What would happen is easy to see. Just like the engineer

who forgot that his goal was to build a tower... You would not reach your goal because you forgot what your goal was.

The same thing happens when you learn something. If you don't know what you will be able to do after having learned (play the guitar, make a bird's cage, compute the area of a triangle) it will be difficult, if not impossible, to learn. For example, if you don't know that your goal is to add numbers as, say, 342 + 769, you will not understand why you must add the numbers in the right column, keep the units if necessary, then add the numbers in the second column, etc. Moreover, at the end of the lesson, you will be unable to judge whether you have reached your goal because you don't know what your goal was! Remember that before you begin to learn something new you must think about what it is that will help you do what you are going to learn.

EXERCISES (Fill in the blanks and check your responses with the ones given at the end of the text.)

1. Peter takes guitar lessons. What is his goal?

_____

_____

2. Mark learns how to divide three-digit numbers by two-digit numbers. What is his goal?

_____

_____

3. Before you begin to learn something, what must you think about first?

_____

_____

4. Roger is presently studying grammar. The following are three sentences taken by chance from a page. Circle the number of the sentence that tells him what he will be able to do after he has learned.

   1. In a sentence, the verb agrees with the subject.

   2. A sentence is a set of words which represent a complete idea. The verb is the word which describes the state or action of the subject. The subject is a word or group of words that represent the person or thing about which the verb describes the state or action.

   3. You will be able to write correctly words such as the ones underlined in sentences such as:
   " The children were friendly."
   " Paul eats a lot."

STEP 2: THINK ABOUT WHAT YOU ALREADY KNOW THAT CAN HELP YOU LEARN THE NEW TASK

Once the engineer has established his goal, he verifies if he has the materials needed to reach his goal. Likewise, after you have decided what you will be able to do after learning (step 1), you need to examine if you have the knowledge needed to reach your goal (step 2).

Here is an example to help you understand the importance of this second step. Imagine you want to teach Peter, who is in the first grade, how to add fractions.

You say to him: "In order to add fractions you reduce the two fractions to the same denominator and then you add the numerators." You have no doubt that Peter will not be able to do it. The reason is simple. Peter does not have the knowledge which he needs to have before he can learn to add fractions. He does not know what a fraction is, what a numerator and a denominator are, or how to change the denominator of a fraction. Probably he may not even know how to add. Because the learning of something new rests upon some previous knowledge, you must make sure that you have the previous knowledge. Before you learn how to compute the perimeter of a rectangle, your teacher will say to you: "remember what the base of a rectangle is and its height." If you don't remember what the height of a rectangle is, you should raise your hand and ask him. Otherwise it will be difficult for you to learn the new task. In most the same way, you must be very attentive when you read your Geometry book. Before you study the section about the computation of the perimeter of a rectangle you should re-read in the previous chapter or paragraph what perimeter, rectangle, base and height are. Trying to learn something new without having the previous necessary knowledge is just like trying to build a tower without having the materials or trying to build the third floor of the tower without having built the second.

EXERCISES

1. This is a detailed division operation. Think about how the computation is done and tell me two things you should know

$$\begin{array}{r} 112 \\ \underline{8} \\ 32 \\ \underline{32} \\ 0 \end{array} \qquad \frac{4}{28}$$

before you could learn how to compute such division problems.

_____

_____

2. You open your Geometry book on page 50 and read this: "To obtain the area of a rectangle, multiply the base of the rectangle by its height."

   a) If you decide to learn this, what would your goal be?

   _____

   _____

   b) What should you remember in order to understand what is being explained?

   _____

   _____

3. The two following paragraphs are part of a Geometry course. What seems to be the most logical order of studying these paragraphs? To learn A first and then B, or to learn B first and then A?

   A - The area of an hexagon is obtained by multiplying the side of the hexagon by the apothem and multiplying the result obtained by 6.

   B - The area of a figure is its surface. An hexagon is a figure with 6 sides. The sides of an hexagon are the lines that limit the surface of the hexagon. The apothem is a line that connects the center of an hexagon and the middle of a side.

   Explain briefly the reason for the order you have chosen.

   _____

   _____

STEP 3: MAKE SURE YOU KNOW HOW TO PROCEED

When the engineer has verified if he has the materials necessary to build his tower, he assembles the materials according to a plan. It happens the same when you learn a new concept. The third step is that you decide in what way you will combine the knowledge you have in order to form a new one. Let me give you an example. Remember when you learned to multiply fractions. After telling you that the goal for that lesson was to make you able to multiply fractions (step 1), your teacher assured himself that you knew what a fraction, a numerator and a denominator were, and that you could multiply (step 2). Do you think those two steps would be sufficient for you to reach your goal? No, you would need the information about what to do to multiply fractions. It was necessary to tell you that "to multiply fractions, multiply the numerators, then the denominators." It was also necessary to give you examples, like: "If you want to multiply 2/3 by 4/5, multiply 2 by 4 and 3 by 5, and then you'll have the answer 8/15." Step 3 then consists of putting together what you already know (fraction, numerator, denominator, multiply) to learn something new (how to multiply fractions).

As you may have realized, you do this by asking for the information on "how to do it."

EXERCISES

1. Peter has no difficulty in multiplying numbers of many digits, like 256 and 398. He knows what a decimal is and can add decimals. However, when he needs to multiply decimals such as 3.98 by 25.6 he does not know where to place the decimal point in the answer. Tell me what it would be necessary to teach Peter in order to enable him to do that kind of multiplication.

_____

_____

_____

2. Connect with a line the sentences in the left column that refer to the sentences in the right column.

a) a description of what you can do after having learned	1. To obtain the area of a triangle, multiply the base by the height and divide the result by 2.
b) previous knowledge that you must remember	2. You will be able to compute the surface of a triangle.
c) an explanation about what to do	3. A triangle is a figure with three sides. The base of the triangle is the side opposite to the top, etc.

3. You know that when you want to learn something new you must first "think about what you will be able to do afterwards." (step 1) Then you must "remember previous knowledge that will help you in learning the new knowledge (step 2). Then you must "look for an

explanation on what to do." Imagine you have decided to learn how to compute the circumference of a circle. Can you tell me in what order you have to study the three following paragraphs? Answer by writing whether the paragraphs must be studied in the order 123, 321, 132, etc. You do not have to learn what each paragraph contains. Just indicate the order in which those paragraphs should be learned.

1. The circumference of the circle is obtained by multiplying the radius of the circle by 7.28.
2. The circumference of the circle is the curved line that delimits the surface of the circle. The radius of a circle is the straight line that goes from the circumference to the center of the circle, etc. etc.
3. When you finish, you will be able to compute the measurement of the circumference of a circle.

Answer _____

STEP 4: VERIFY IF YOU HAVE REACHED YOUR GOAL

When the engineer builds his tower he constantly verifies whether he is going towards his goal. After building the first floor, he checks if everything is correct, if everything is straight and secure. If the goal was not reached, he makes changes and if necessary begins all over again. This checking is fundamental. It is the only way of making sure that his goal or goals were reached. The same happens when you learn. The only way you can know if you have really learned something is to verify, when you finish studying, whether you are able to do what you intended.

If your goal were to add fractions, the only way of verifying if you have reached that goal is by adding fractions and checking your answers with those on your book or those given by your teacher. If your answers are correct you may conclude that you know how to add fractions. Remember that the only way for you to know whether you have reached your goal is to test yourself.

EXERCISES

1. The goal of a Math course is to divide fractions. Peter is reminded of what a fraction is, what a numerator and a denominator are and how to multiply fractions. It is explained to him that to divide fractions such as 2/3 and 5/6 he must invert the second fraction and then multiply the two fractions.

Example: if you want to divide 2/3 by 5/6 you write 2/3 x 6/5 and then obtain 12/15. Peter says that now he knows how to divide fractions. What must you do to make sure he can?

_____

_____

2. You have learned that to learn something new four successive steps were needed. Write in the blanks the missing words for each of those steps.

   1. You must think of what you will be able to _____ _____ having learned.
   2. You must _____ previous knowledge that will help you learn the new knowledge.
   3. You must ask for the _____ about how to _____.
   4. You must _____ whether you have reached your goal.

3. Each of the paragraphs below contain part of a course. Tell me the order in which those paragraphs should be learned.

   1. Write the sentence correctly. [The apples (is/are) good.]
   2. In a sentence, the verb agrees with the subject.
   3. A sentence is a set of words which represent a complete idea. The verb is the word that describes the state or action of the subject. The subject is a word or group of words that represent the person or thing about which the verb describes the state or the action.
   4. When you finish, you will be able to write the verb of a sentence correctly.

Answer _____

4. Same as question 3.

   1. The mile is a unit of length.

      The hour is a unit of time.

   2. You will be able to compute the average speed of a car.

   3. What is the speed of a car that traveled 300 miles in 5 hours?

   4. To obtain the average speed of a car, divide the number of miles traveled by the number of hours taken to travel that distance. If the number of miles is 360 and the car took 6 hours to travel that distance, the average speed will be 60 miles an hour.

   Answer _____

5. Each of the following paragraphs constitute a small part of a course. Write the order in which these paragraphs should be learned.

   1. Add the following fractions: 2/3 + 2/15 = ? 1/9 + 2/3 = ?

   2. You will be able to add fractions of different denominators.

   3. A fraction is part of a unit. The numerator is the term of a fraction placed above the horizontal line and it indicates how many parts equal to a unit the fraction contains. The denominator of a fraction is the one of the two numbers that indicates in how many equal parts the unit will be divided. To add fractions we add the numerators and then the denominators. To reduce the fractions to the same denominator, we etc.

   4. To add fractions that have different denominators (e.g. 3/5 + 1/8) reduce the fractions to the same denominator and then add the fractions as usual.

   Answer _____

6. Each of the following paragraphs constitute a small part of a course. Write the order in which these paragraphs should be learned.

   1. You will be able to punctuate correctly sentences such as "How are they" "Where are they going" .

   2. When a sentence is written in the interrogative form, it must end with a question mark.

   3. A sentence is written in the interrogative form when it is written as a question. The symbol ? represents a question mark.

   4. Place the question mark where necessary:
      a) Peter goes to the beach ___
      b) Is Claude all right ___
      c) Allan saw him ___
      d) Is Michael learning tonight ___

   Answer _____

7. Same as question 6.

   1. A leaf is 8 inches long. How many centimeters long is it?

   2. To convert inches into centimeters multiply the inches by 2.5.

   3. An inch is a measure of length. A centimeter is a measure of length (etc., etc.)

   4. You will be able to convert inches into centimeters.

   Answer _____

ANSWER KEY

STEP 1 (pages 2 and 3)

1. Peter's goal is to play the guitar.

2. Divide three-digit numbers by two-digit numbers

3. What you will be able to do after learning.

4. Sentence 3 tells Peter what he will be able to do after having learned.

STEP 2 (pages 4 and 5)

1. Multiply, subtract

2. a) Compute the area of a rectangle

   b) You must remember what a rectangle is, what base and height are, you must remember how to multiply.

3. The paragraphs should be learned in the order BA. That is easy to understand. If you want to understand what is explained in paragraph A you have to know and remember what is explained in paragraph B.

STEP 3 (pages 7 and 8)

1. It would be necessary to tell Peter how to place the decimal point.

2. Paragraph 2 in the right column indicates what you will be able to do after learning. Paragraph 3 allows you to recall knowledge you already have and must remember before going on to the explanations. Paragraph 1 gives you the explanations on what to do.

3. In this short Geometry course, sentence 3 tells you what you will be able to do after having learned: "compute how to measure the circumference of a circle." Paragraph 2 recalls what you must know before you learn how to compute the circumference of a circle. This way you must recall what a circumference is, and a radius. You must know how to multiply, etc. Paragraph 3 tells you how to combine old knowledge to form new knowledge. The three sentences should be learned in the order 321.

STEP 4 (pages 9, 10, 11, and 12)

1. Ask Peter to divide fractions.

2. 1. do before

   2. remember

   3. explanations, do.

   4. verify

3. In this short Math course, paragraph 3 indicates what you will be able to do afterwards: "transform ordinary fractions into decimal fractions." In reading paragraph 3 you realize it represents step 1. Paragraph 4 helps you remember what you already know that will help you learn the new materials. Paragraph 4 then refers to step 2. Paragraph 1 tells you what to do to transform ordinary fractions into decimal fractions. This paragraph then represents step 3. Finally, paragraph 2 will allow you to check if you reached your goal. That paragraph refers to step 4. Those paragraphs should be learned in the order 3412.

4. Paragraph 2 reads "you will be able to compute the average speed of a car." That is what you will be able to do after learning (step 1). Paragraph 1 reminds you of the knowledge which is essential in order to learn the new material (step 2). Paragraph 4 explains what to do to compute the average speed. Thus, that paragraph illustrates step 3. Paragraph 3 will allow you to check if you reached your goal. It refers to step 4, then. Those paragraphs should be learned in the order 2143.

5. Answer questions 5, 6 and 7.
   The answers for these questions will be given to you later on.

APPENDIX D

LEARNING STRATEGY POSTTEST

LEARNING STRATEGY POSTTEST

The following test intends to evaluate your ability to learn. Each question consists of a portion of a Math course, an English course or any other subject. Indicate, according to your opinion, the order in which the paragraphs of each question should be learned. Write your answers in the spaces provided after each question, using the numbers 1, 2, 3, or 4. You do not have to learn the content of each paragraph nor to answer the questions that a paragraph may contain. You must only write the order in which you would learn the paragraphs. For example, if you think the paragraphs in one question should be learned in the order 3214, write 3214 in the space provided.

Question #1.

1. To obtain the perimeter of a regular pentagon, multiply the length of one side by 5. Thus, if one side is 6-feet long, the perimeter will be 30 feet.

2. What is the perimeter of a pentagon 10-feet long on one side?

3. You will be able to compute the perimeter or a pentagon.

4. The perimeter of a geometric figure is the shape of the figure. A regular pentagon is a closed figure with 5 equal sides. The side of a pentagon is one of the straight lines that limit the area of the pentagon.

Answer _____

Question #2.

1. To determine the longitude of a point on a map we take a perpendicular line joining the point and the scale of longitudes. To determine the latitude of a point, we take a perpendicular line joining the point and the scale of latitudes.

2. You will be able to locate, using numbers, a place on a map.

3. This is the map of the city of Quebec and here is a ruler. Draw the point supposing you are at the place marked with an X.

4. To locate a place on a map, we determine the longitude and latitude of this point on the map.

Answer _____

Question #3.

1. In French, the adjective agrees in gender and number with the noun to which it refers.

2. An adjective is a word which is attached to a noun in order to qualify it or to determine it. The gender of a word is a form that the word takes to indicate the sex of living things and to differentiate the nouns of things. The number is a quality of the words to represent the idea of unit or plurality.

3. Write correctly the following sentence:
"Les pommes que Anne a ceuillies sont _____."
(bon, bonnes, bons, bonne)

4. You will be able to write correctly the adjective of a sentence in French.

Answer _____

Question #4.

1. How much is 82^{o} Farenheit in degrees Celsius?

2. You will be able to transform temperature in the scale Farenheit into temperatures in the scale Celsius.

3. The degree Farenheit is a unit of temperature. The degree Celsius is a unit of temperature. To multiply a fraction by a whole number, multiply the numerator of the fraction by the whole number to obtain a new fraction of different numerator but of same denominator as the first one, etc.

4. To transform degrees Farenheit into degrees Celsius, subtract 32 from the degrees Farenheit and multiply the result by 9/5. For example, to transform 52^{o} F into degrees Celsius, we subtract 52-32 = 20. And then multiply 20 x 9/5 = 36. The answer is 36^{o} Celsius.

Answer _____

Question #5.

1. To transform a fraction expression such as 5 3/4 into a single fraction, multiply the denominator of the expression by the whole number (4 x 5 = 20). Then add the result obtained to the numerator of the fraction. Finally, write the result obtained over the denominator. In this case we obtained 23/4.

2. You will be able to transform an expression such as 6 2/5 into the form of an ordinary fraction.

3. What is the ordinary fraction that corresponds to 7 3/4?

4. A fraction expresses a part of the unit. A numerator is the term of the fraction placed over the horizontal line and it indicates how many parts it contains. The denominator is the one of the two terms which defines in how many equal parts the unit is supposedly divided.

Answer _____

APPENDIX E

INTRODUCTION TO THE SECOND PART OF THE EXPERIMENT

INTRODUCTION TO THE SECOND PART OF THE EXPERIMENT

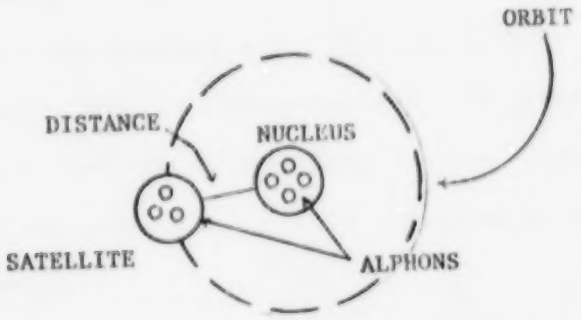
In this second part of the experiment you will be asked to study the science of the Xenograde systems. It is a science which is easy and fun to learn and you can learn it in a short time.

For your information, a Xenograde system resembles our solar system but it is infinitely smaller. In the center of the system there is a nucleus around which a satellite gravitates. The goal of this part of the experiment is to have you learn the laws that regulate the Xenograde systems.

You will not utilize the concepts of this science in everyday life but this study will allow you to have a very clear idea of what you will be learning in Physics and Chemistry once you enter High-school. Give the best of you while participating in this experiment. You will be helping your friends, your teachers and yourself.

So, let us start with a brief introduction to the science of the Xenograde systems.

A Xenograde system resembles our solar system except that it is less complex and infinitely smaller. A Xenograde system contains a NUCLEUS at the center and a SATELLITE which gravitates around the nucleus (see figure). Inside the nucleus and the satellite there are particles which will be called ALPHONS.



When a Xenograde system travels through space it meets certain forces. These forces act upon it and make the distance between the satellite and the nucleus change. The following table illustrates the evolution of a Xenograde system when it meets a force field.

TIME	DISTANCE
0	15
1	12
2	9
3	6
4	3
5	0
6	2
7	4

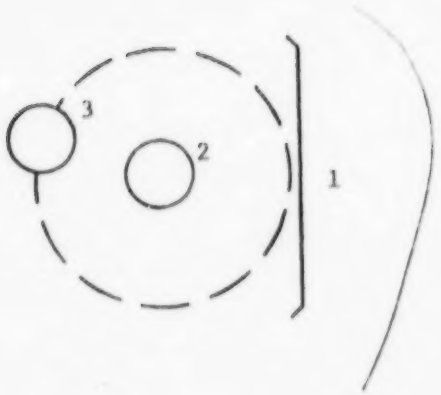
As you realize, the distance satellite-nucleus changes with time. When the system enters a force field (time 0) the distance satellite-nucleus is 15. At time 2, the distance is 9. At time 3, the distance is 6. At time 5, the distance is 0 and then there is a collision of satellite and nucleus. After the collision, the distance increases. Thus, at time 6 the distance is 2 and at time 7 the distance is 4. The goal of this course is to explain to you how a Xenograde system works in the presence of a force field and to teach you to anticipate certain events. But before starting to learn the science of the Xenograde systems, answer the following test.

APPENDIX F

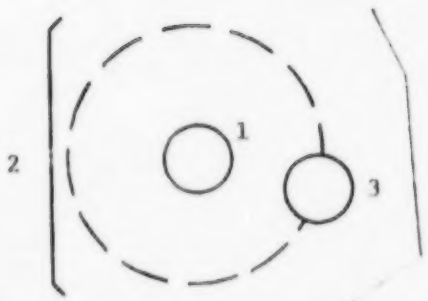
TEST OF PREREQUISITE SKILLS

TEST OF PREREQUISITE SKILLS

1. What is the number that identifies the nucleus of the Xenograde system?

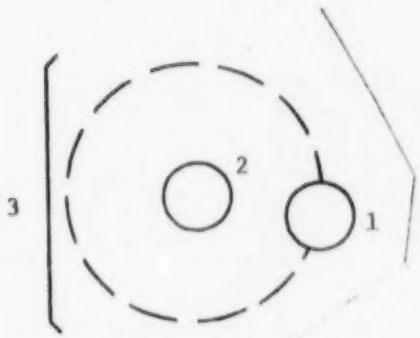


a) Answer _____

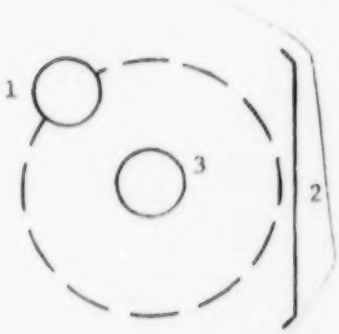


b) Answer _____

2. What is the number that identifies the satellite of the Xenograde system?



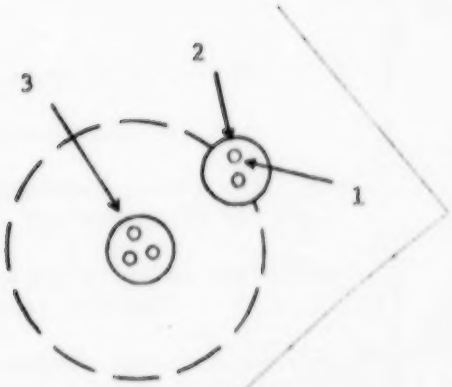
a) Answer _____



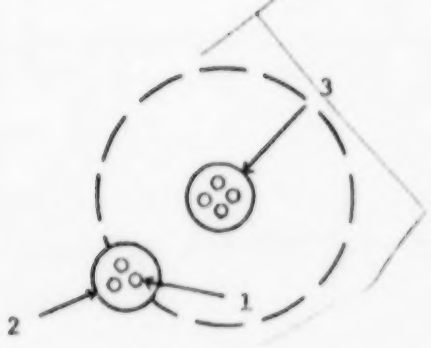
b) Answer _____

3. What is the number that identifies an alphon?

a) Answer _____

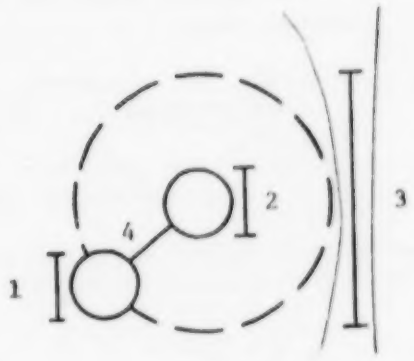


b) Answer _____

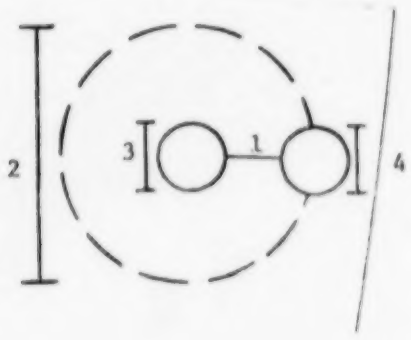


4. What is the number that represents the distance satellite-nucleus?

a) Answer _____



b) Answer _____



5 a) What of the following definitions better describes what the table of evolution of a Xenograde system is?

1. The table of evolution of a Xenograde system consists of a description of the nucleus of the Xenograde system.

2. The table of evolution of a Xenograde system describes the state of the system after a collision.

3. The table of evolution of a Xenograde system furnishes the distance satellite-nucleus at each moment after the system enters a force field.

4. The table of evolution of a Xenograde system consists of a description of the satellite at a given time.

5. None of the above responses.

Answer _____

b) Which of the following statements better describes what the table of evolution of a Xenograde system is?

1. The table of evolution of a Xenograde system consists of a picture of the Xenograde system at a given moment.

2. The table of evolution of a Xenograde system furnishes the distance satellite-nucleus for all given moments.

3. The table of evolution of a Xenograde system indicates the distance between the alphons in the nucleus.

4. The table of evolution of a Xenograde system furnishes a graphic representation of the state of the system after a collision.

5. None of the above responses.

Answer _____

6. Circle the even numbers in the following list:
   7, 12, 11, 9, 8, 6, 12, 15, 18, 17

7. Circle the odd numbers in the following list:
   8, 14, 13, 5, 2, 1, 12, 3, 10, 9, 21

APPENDIX G

XENOGRADE SCIENCE INSTRUCTIONAL MATERIALS

XENOGRADE SCIENCE INSTRUCTIONAL MATERIALS

TASK 1

OBJECTIVE

Given a written or pictorial description of a Xenograde System, you will be able to indicate the ACN (Alphon Count of the Nucleus) of the System.

SKILLS TO BE REMEMBERED

Remember that...

Nucleus: a particle situated at the center of a Xenograde System.

Satellite: a particle that revolves around the nucleus of a Xenograde System.

Alphons: particles contained inside the nucleus and the satellite of a Xenograde System.

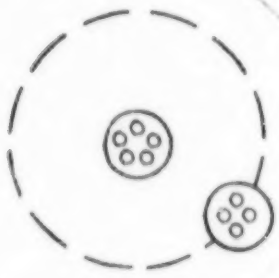
STATEMENT

The ACN or Alphon Count of the Nucleus in a Xenograde System is the number of particles contained inside the nucleus of the System.

DEMONSTRATION

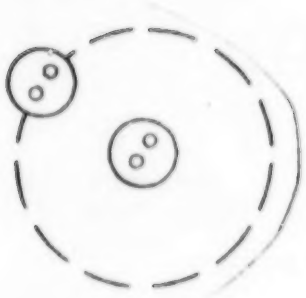
Alphon Count of the Nucleus

The ACN of the following Xenograde System is 5 because there are 5 Alphons inside the nucleus of the satellite.



PRACTICE 1

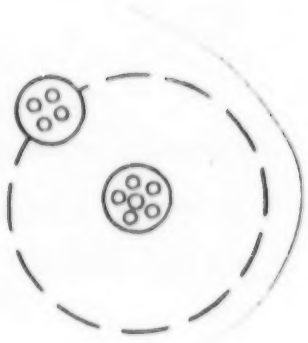
What is the ACN of the following Xenograde System?



Answer _____

TEST 1

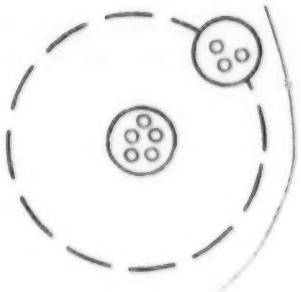
What is the ACN of the following Xenograde System?



Answer _____

TEST 2

What is the ACN of the following Xenograde System?



Answer _____

TASK 2

OBJECTIVE

Given a written or pictorial description of a Xenograde System, you will be able to indicate the ACS (Alphon Count of the Satellite) of the System

SKILLS TO BE REMEMBERED

Remember that...

Nucleus: a particle situated at the center of a Xenograde System.

Satellite: a particle that revolves around the nucleus of a Xenograde System.

Alphons: particles contained inside the nucleus and the satellite of a Xenograde system.

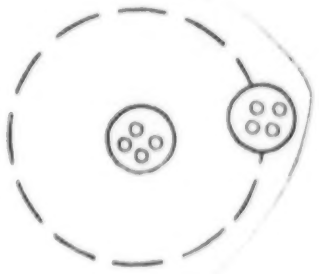
STATEMENT

The ACS or Alphon Count of the Satellite of a Xenograde System is the number of alphon particles contained in the satellite of the system.

DEMONSTRATION

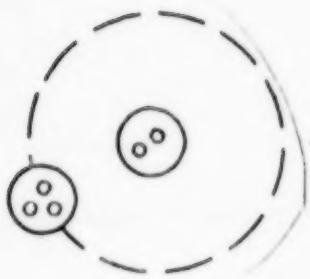
Alphon Count of the Satellite

The ACS of the Xenograde System pictured here is 4.



PRACTICE 1

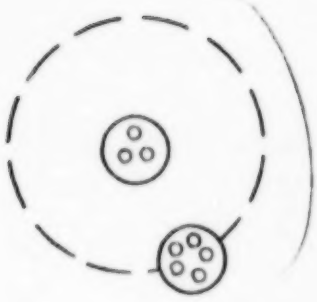
What is the ACS of the following Xenograde System?



Answer _____

TEST 1

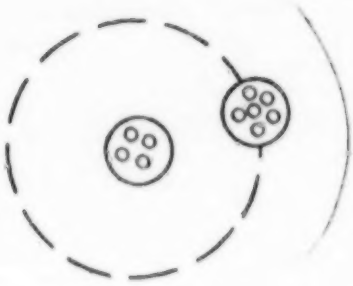
What is the ACS of the following Xenograde System?



Answer _____

TEST 2

What is the ACS of the following Xenograde System?



Answer _____

TASK 3

OBJECTIVE

You will be able to indicate from among a number of descriptions the one that describes a Force Field (F.F.).

SKILLS TO BE REMEMBERED

Remember that...

Force: anything capable of promoting action, or producing an effect.

STATEMENT

A F.F. or Force Field is what acts upon a Xenograde System changing the distance nucleus-satellite.

DEMONSTRATION

If a Xenograde System meets a F.F. (Force Field) of intensity 1 this will change the distance satellite-nucleus.

PRACTICE 1

Circle the number beside the description of a F.F. or Force Field.

1. A F.F. is a change in the distance between nucleus and satellite.
2. A F.F. is the distance between nucleus and satellite.
3. A F.F. is what produces a change in the distance nucleus-satellite.
4. None of the above responses.

TEST 1

Circle the number beside the description of a F.F. or Force Field.

1. The F.F. is a force that decreases the number of alphons in the nucleus.
2. The F.F. is a force that modifies the distance satellite-nucleus.
3. The F.F. is a force that modifies the weight of the nucleus.
4. None of the above responses.

TEST 2

Circle the number beside the description of a F.F. or Force Field.

1. The F.F. is a force that changes the number of alphons in the nucleus.
2. The F.F. is a force that changes the number of alphons in the satellite.
3. The F.F. is the distance between the nucleus and the satellite.
4. None of the above responses.

TASK 4

OBJECTIVE

You will be able to indicate on a table representing the evolution of a Xenograde System the time at which a particular event occurs.

SKILLS TO BE REMEMBERED

Remember that...

Table of a Xenograde System: table containing rows and columns of numbers represenging the evolution of a Xenograde System. The left column indicates the time (starting at 0) of the different events that occur in the System.

STATEMENT

The time of an event is the moment in which a particular event or occurrence occurs in a Xenograde System.

DEMONSTRATION

If we look at the Table we see that for time 2 the distance satellite-nucleus was 56.

F.F. = 4

T	ACN	BLIP TIME	DIST.	ACS
0	8		64	1
1	8		60	1
2	8		56	1
3	8		52	1
4	8		48	1
5	8		44	1
6	8		40	1
7	8		36	1

PRACTICE

F.F. = 1

What is the time of the System when distance is 36?

Answer _____

T	ACN	BLIP TIME	DIST.	ACS
0	3		60	6
1	3		48	6
2	3		36	6
3	3		24	6
4	3		12	6

TEST 1

F.F. = 3

At what time is the distance satellite-nucleus 24?

Answer _____

T	ACN	BLIP TIME	DIST.	ACS
0	3		36	3
1	3		27	3
2	3		18	3
3	3		9	3
4	2		0	4
5	2		12	4
6	2		24	4
7	2		36	4

TEST 2

F.F. = 1

At what time is the distance satellite-nucleus equal to 0?

Answer _____

T	ACN	BLIP TIME	DIST.	ACS
0	3		15	3
1	3		12	3
2	3		9	3
3	3		6	3
4	3		3	3
5	4		0	2
6	4		2	2
7	4		4	2

TASK 5

OBJECTIVE

Presented with a Table that shows the evolution of a Xenograde System you will be able to describe the state of the System at a time T, by telling the F.F., ACN, ACS and the distance satellite-nucleus.

SKILLS TO BE REMEMBERED

Remember that...

ACN: number of alphons contained in the nucleus of a Xenograde system.

ACS: number of alphons contained in the satellite of a Xenograde System.

F.F.: what acts upon a Xenograde System changing the distance satellite-nucleus.

Distance-satellite-nucleus: distance between the satellite and the nucleus of a Xenograde system.

Time of an event: moment at which a particular occurrence or event occurs in the Xenograde System.

STATEMENT

The state of a Xenograde System at a time T is the description of the Xenograde System by means of the following values: F.F., ACN, ACS and the distance satellite-nucleus.

DEMONSTRATION

Here is a Table of evolution of a Xenograde System. Looking at the Table we see that the state of the Xenograde System at time 4 was

F.F. = 2; ACN = 4; ACS = 3 and distance satellite-nucleus - 6

F.F. = 2

T	ACN	BLIP TIME	DIST.	ACS
0	3		24	4
1	3		16	4
2	3		8	4
3	4		0	3
4	4		6	3
5	4		12	3
6	4		18	3
7	4		24	3

PRACTICE

Describe the state of the Xenograde System at time T=4

Answer _____

F.F. = 2

T	ACN	BLIP TIME	DIST.	ACS
0	3		24	4
1	3		16	4
2	3		8	4
3	4		0	3
4	4		6	3
5	4		12	3
6	4		18	3

TEST 1

Describe the state of the Xenograde System at time T=5

Answer _____

F.F. = 2

T	ACN	BLIP TIME	DIST.	ACS
0	3		24	4
1	3		16	4
2	3		8	4
3	4		0	3
4	4		6	3
5	4		12	3
6	4		18	3

TEST 2

Describe the state of Xenograde System at time T=48.

Answer _____

F.F. = 1

T	ACN	BLIP TIME	DIST.	ACS
-	-		-	-
-	-		-	-
47	5		14	7
48	5		7	7
49	6		0	6

TASK 6

OBJECTIVE

You will be able to indicate the BLIP TIME of a Xenograde System by looking at a Table describing the evolution of the System.

SKILLS TO BE REMEMBERED

Remember that...

Distance satellite-nucleus: distance that separates the satellite from the nucleus of a Xenograde System.

State of a Xenograde System: The state of a Xenograde System at a time T is the description of the Xenograde System by means of the following values: F.F., ACN, ACS, and the distance satellite-nucleus.

STATEMENT

The BLIP TIME is the time T in which the satellite and the nucleus suffer a collision; the distance satellite-nucleus at this time is zero.

DEMONSTRATION

In this case, the BLIP TIME is 3.

Note that the distance satellite-nucleus is 0.

F.F. = 2

T	ACN	BLIP TIME	DIST.	ACS
0	3		24	4
1	3		16	4
2	3		8	4
3	4		0	3
4	4		6	3
5	4		12	3
6	4		18	3
7	4		24	3

PRACTICE

F.F. = 3

What is the BLIP TIME?

T	ACN	BLIP TIME	DIST.	ACS
0			90	
1			75	
2			60	
3			45	
4			30	
5			15	
6			0	
7			18	

Answer _____

TEST 1

F.F. = 2

What is the BLIP TIME?

T	ACN	BLIP TIME	DIST.	ACS
0	3		24	4
1	3		16	4
2	3		8	4
3	4		0	3
4	4		6	3
5	4		12	3
6	4		18	3

Answer _____

TEST 2

F.F. = 1

What is the BLIP TIME?

T	ACN	BLIP TIME	DIST.	ACS
0			15	
1			12	
2			9	
3			6	
4			3	
5			0	
6			2	
7			4	

Answer _____

TASK 7

OBJECTIVE

The value of F.F. being 1 and given the values of ACS and the distance satellite-nucleus at a given moment, you will be able to indicate what the distance satellite nucleus will be in the following moment.

SKILLS TO BE REMEMBERED

Remember that...

Distance satellite-nucleus: distance between the satellite and the nucleus of a Xenograde System.

ACS: number of alphons present in the satellite of a Xenograde System.

F.F: what acts upon the Xenograde System changing the distance satellite-nucleus.

Time of an event: moment at which a particular occurrence or event occurs in a Xenograde System.

STATEMENT

When F.F. = 1 the distance satellite-nucleus at a given moment is obtained by subtracting the value of ACS at the preceding moment from the distance satellite-nucleus at the preceding time.

DEMONSTRATION

When F.F. = 1, the distance at time 4 is obtained by subtracting ACS = 3 from the distance at the preceding moment. We obtain, then, 12 - 3 = 9

F.F. = 1

T	ACN	BLIP TIME	DIST.	ACS
0	5		21	3
1	5		18	3
2	5		15	3
3	5		12	3
4	5		9	3

PRACTICE 1

F.F. = 1

T	ACN	BLIP TIME	DIST.	ACS
-	-		-	-
-	-		-	-
-	-		-	-
5	7		3	3
6			?	

What is the distance satellite-nucleus at time T = 6?

Answer _____

TEST 1

F.F. = 1

T	ACN	BLIP TIME	DIST.	ACS
-	-		-	-
-	-		-	-
4	7		3	3
5			?	

What is the distance satellite-nucleus at time T = 5?

Answer _____

TEST 2

F.F. = 1

T	ACN	BLIP TIME	DIST.	ACS
2	6		16	8
3			?	

What is the distance satellite-nucleus at time T = 3?

Answer _____

TASK 8

OBJECTIVE

The value of ACS being 1, and given the values of F.F. and the distance satellite-nucleus for a given moment, you will be able to indicate what the distance satellite-nucleus will be for the next moment.

SKILLS TO BE REMEMBERED

Remember that...

Distance satellite-nucleus: distance between satellite and nucleus of a Xenograde System.

ACS: number of alphons present in the satellite of a Xenograde System.

F.F.: what acts upon a Xenograde System changing the distance satellite-nucleus.

Time of an event: moment at which a particular occurrence or event occurs in a Xenograde System.

STATEMENT

When ACS = 1, the distance satellite-nucleus at a given moment is obtained by subtracting the value of F.F. from the distance satellite-nucleus at the preceding moment.

DEMONSTRATION

In the Table, ACS = 1; the distance at time 3 is obtained by subtracting F.F. = 8 from the distance at the preceding moment. We, then, obtain 16 - 8 = 8

F.F. = 8

T	ACN	BLIP TIME	DIST.	ACS
0	6		32	1
1	6		24	1
2	6		16	1
3	6		8	1

PRACTICE 1

F.F. = 3

T	ACN	BLIP TIME	DIST.	ACS
-	-		-	-
-	-		-	-
-	-		-	-
6	4		9	1
7			?	

What is the distance satellite-nucleus at time T = 7?

Answer _____

TEST 1

F.F. = 4

T	ACN	BLIP TIME	DIST.	ACS
-				
-				
-				
4	5		12	1
5			?	

What is the distance satellite-nucleus at time T = 5?

Answer _____

TEST 2

F.F. = 3

T	ACN	BLIP TIME	DIST.	ACS
-				
-				
-				
5	7		3	1
6			?	

What is the distance satellite-nucleus at time T = 6?

Answer _____

TASK 9

OBJECTIVE

Given the values of F.F., ACS and the distance satellite-nucleus at a given moment, you will be able to compute the distance satellite-nucleus at the next moment.

SKILLS TO BE REMEMBERED

Remember that...

Distance satellite-nucleus: distance between the satellite and the nucleus of a Xenograde System.
ACS: number of alphons present in the satellite of a Xenograde System.
Time of an Event: moment at which an occurrence or event occurs in a Xenograde System.

STATEMENT

The distance satellite-nucleus at a given moment is obtained by multiplying F.F. by ACS and by subtracting the result from the distance satellite-nucleus at the preceding moment.

DEMONSTRATION

In the Table F.F. = 3 and ACS = 5 at time 1. To obtain the distance at time 2, we multiply 3 x 5 = 15 and subtract 15 from the distance at time 1.

We, then, obtain 75 - 15 = 60.
The distance at time 2 is 60.

F.F. = 3

T	ACN	TIME	DIST.	ACS
0	7		90	5
1	7		75	5
2	7		60	5
3	7		45	5
4			30	

PRACTICE 1

F.F. = 2

T	ACN	BLIP TIME	DIST.	ACS
0	2		72	3
1	2		66	3
2	2		60	3
3			?	

What is the distance satellite-nucleus at time T = 3?

Answer _____

TEST 1

F.F. = 3

T	ACN	BLIP TIME	DIST.	ACS
0	3		30	2
1	3		24	2
2	3		18	2
3			?	

What is the distance satellite-nucleus at time T = 3?

Answer _____

TEST 2

F.F. = 4

T	ACN	BLIP TIME	DIST.	ACS
0			24	3
1			?	

What is the distance satellite-nucleus at time T = 3?

Answer _____

TASK 10

OBJECTIVE

Given the values of ACN at a given moment, you will be able to predict the value of ACN and ACS at the next moment.

SKILLS TO BE REMEMBERED

Remember that...

ACN: number of alphons contained in the nucleus of a Xenograde System

ACS: number of alphons contained in the satellite of a Xenograde System.

Time of an event: moment at which a particular occurrence or event occurs in a Xenograde System.

STATEMENT

The value of ACN and ACS does not change during the normal evolution of a Xenograde System. Only one collision can change the value of ACN and ACS.

DEMONSTRATION

Note that the values of ACN and ACS are the same at different distances satellite-nucleus.

F.F. = 3

T	ACN	BLIP TIME	DIST.	ACS
0	7		90	2
1	7		84	2
2	7		78	2
3	7		72	2
4	7		66	2

PRACTICE 1

What are the values of ACN and ACS at time T = 1?

Answer: ACS = _____
ACN = _____

F.F. = 4

T	ACN	BLIP TIME	DIST.	ACS
0	5		24	3
1	?		12	?

TEST 1

What are the values of ACN and ACS at time T = 5?

Answer: ACS = _____
ACN = _____

F.F. = 3

T	ACN	BLIP TIME	DIST.	ACS
0	0		54	3
1	0		45	3
2	0		36	3
3	0		27	3
4	0		18	3
5	?		9	?

TEST 2

What are the values of ACN and ACS at time T = 3?

Answer: ACS = _____
ACN = _____

F.F. = 3

T	ACN	BLIP TIME	DIST.	ACS
0	3		30	2
1	3		24	2
2	3		18	2
3	?			?

TASK 11

OBJECTIVE

Given the values of ACN and ACS before collision, you will be able to predict the values of ACN and ACS after collision when the blip time is an even number.

SKILLS TO BE REMEMBERED

Remember that...

Even number: a number which is divisible by 2.
ACN: number of alphons contained in the nucleus of a Xenograde System
ACS: number of alphons contained in the satellite of a Xenograde System.
BLIP TIME: the time T when the satellite and the nucleus enter in collision. The distance satellite-nucleus is then 0.

STATEMENT

When the BLIP TIME is an even number, the ACN decreases of 1 and the ACS increases of 1.

DEMONSTRATION

The Table indicates that the BLIP TIME is 6.

Because 6 is an even number, ACS increases of 1 and ACN decreases of 1.

F.F. = 3

T	ACN	BLIP TIME	DIST.	ACS
0	7		90	5
1	7		75	5
2	7		60	5
3	7		45	5
4	7		30	5
5	7		15	5
6	6	6	0	6
7	6		18	6

PRACTICE 1

What are the values of ACN and ACS at time T = 4?

Answer: ACN _____
ACS _____

F.F. = 3

T	ACN	BLIP TIME	DIST.	ACS
0	3		36	3
1	3		27	3
2	3		18	3
3	3		9	3
4	?	4	0	?

TEST 1

What are the values of ACN and ACS at time T = 14?

Answer: ACN _____
ACS _____

F.F. = 3

T	ACN	BLIP TIME	DIST.	ACS
-	-		-	-
-	-		-	-
-	-		-	-
12	3		12	2
13	3		6	2
14	?	14	0	?

TEST 2

What are the values of ACN and ACS at time T = 36?

Answer: ACN _____
ACS _____

F.F. = 2

T	ACN	BLIP TIME	DIST.	ACS
-	-		-	-
-	-		-	-
-	-		-	-
34	3		24	6
35	3		12	6
36	?	36	0	?

TASK 12

OBJECTIVE

Given the value of ACN and ACS before collision, you will be able to predict the value of ACN and ACS when BLIP TIME is an odd number.

SKILLS TO BE REMEMBERED

Remember that...

Odd number: number which is not divisible by 2 (3,5,7,9 are odd numbers).

ACN: number of alphons contained in the nucleus of a Xenograde System.

ACS: number of alphons contained in the satellite of a Xenograde System.

BLIP TIME: the time T when the satellite and the nucleus enter in collision. The distance satellite-nucleus is then 0.

STATEMENT

When the BLIP TIME is an odd number, the ACN increases by 1 and the ACS decreases by 1.

DEMONSTRATION

The Table indicates that the BLIP TIME is 43.

Because 43 is an odd number, ACN increases by 1 and ACS decreases by 1.

F.F. = 3

T	ACN	BLIP TIME	DIST.	ACS
-	-		-	-
-	-		-	-
-	-		-	-
42	3		12	4
43	4	43	0	3

PRACTICE 1

What are the values of ACN and ACS at time T = 5?

Answer: ACN = _____
ACS = _____

F.F. = 2

T	ACN	BLIP TIME	DIST.	ACS
0	3		60	6
1	3		48	6
2	3		36	6
3	3		24	6
4	3		12	6
5	?	5	0	?

TEST 1

What are the values of ACN and ACS at time T = 5?

Answer: ACN = _____
ACS = _____

F.F. = 3

T	ACN	BLIP TIME	DIST.	ACS
-	-		-	-
-	-		-	-
-	-		-	-
4	3		6	2
5	?	5	0	?

TEST 2

What are the values of ACS and ACN at time T = 5?

Answer: ACN = _____
ACS = _____

F.F. = 2

T	ACN	BLIP TIME	DIST.	ACS
-	-		-	-
-	-		-	-
-	-		-	-
3	3		24	6
4	3		12	6
5	?	5	0	?

TASK 13

OBJECTIVE

Given the values of F.F. and ACS you will be able to predict the distance satellite-nucleus after the collision.

SKILLS TO BE REMEMBERED

Remember that...

F.F.: what acts upon a Xenograde System changing the distance satellite-nucleus.

ACS: number of alphons contained in the satellite of a Xenograde System.

Distance satellite-nucleus: distance between the satellite and the nucleus of a Xenograde System.

Time of an event: moment at which a particular occurrence or event occurs in a Xenograde System.

STATEMENT

To obtain the distance at a given moment after the collision, we multiply F.F. by ACS and add the result to the distance satellite-nucleus at the preceding moment.

DEMONSTRATION

To obtain the distance at time 4, we multiplied F.F. x ACS and obtained 6. We add 6 to the distance at T = 3 and obtained 6 as the new distance.

F.F. = 2

T	ACN	BLIP TIME	DIST.	ACS
-	-		-	-
-	-		-	-
2	3		8	4
3	4	3	0	3
4	4		6	3
5	4		12	3
6	4		18	3

PRACTICE 1

What is the distance satellite-nucleus at time T = 7?

Answer _____

F.F. = 2

T	ACN	BLIP TIME	DIST.	ACS
-	-		-	-
-	-		-	-
-	-		-	-
4	8		20	5
5	8		10	5
6	7		0	6
7			?	

TEST 1

What is the distance statellite-nucleus at time T = 7?

Answer _____

F.F. = 3

T	ACN	BLIP TIME	DIST.	ACS
-	-		-	-
-	-		-	-
-	-		-	-
5	7		15	5
6	6	6	0	6
7			?	

TEST 2

What is the distance satellite-nucleus at time T = 44?

Answer _____

F.F. = 3

T	ACN	BLIP TIME	DIST.	ACS
-	-		-	-
-	-		-	-
-	-		-	-
42	5		12	4
43	6	43	0	3
44			?	

TASK 14

OBJECTIVE

You will be able to predict the value of ACN and ACS after the collision, when the value of ACN was 0 before collision and the BLIP TIME was an Even number.

SKILLS TO BE REMEMBERED

Remember that...

ACS: number of alphons in the satellite of a Xenograde System.
ACN: number of alphons in the nucleus of a Xenograde System.
BLIP TIME: time T when the satellite and the nucleus enter in collision. The distance satellite-nucleus is then 0.
Even number: a number divisible by 2.

STATEMENT

When ACN is zero before the collision and the BLIP TIME is an even number, ACN and ACS maintain the same value after the collision.

DEMONSTRATION

F.F. = 2

T	ACN	BLIP TIME	DIST.	ACS
-	-		-	-
-	-		-	-
-	-		-	-
34	0		24	6
35	0		12	6
36	0	36	0	6

Note in the Table that the BLIP TIME is an even number and ACN was 0 before the collision. In this case, ACN and ACS maintain their same values after the collision

PRACTICE 1

What are the values of ACN and ACS at time T = 6?

Answer: ACN = _____
ACS = _____

F.F. = 3

T	ACN	BLIP TIME	DIST.	ACS
-			-	-
-			-	-
-			-	-
4	0		30	5
5	0		15	5
6	?	6	0	?

TEST 1

What are the values of ACN and ACS at time T = 8?

Answer: ACN = _____
ACS = _____

F.F. = 2

T	ACN	BLIP TIME	DIST.	ACS
-				
-				
-				
6	0		16	4
7	0		8	4
8	?	8	0	?

TEST 2

What are the values of ACN and ACS at time T = 42?

Answer: ACN = _____
ACS = _____

F.F. = 1

T	ACN	BLIP TIME	DIST.	ACS
-	-		-	-
-	-		-	-
40	0		14	7
41	0		7	7
42	?	42	0	?

TASK 15

OBJECTIVE

You will be able to predict the maximum distance between the nucleus and the satellite after a collision occurred.

SKILLS TO BE REMEMBERED

Remember that...

Distance satellite-nucleus: the distance between the nucleus and the satellite of a Xenograde System.
Time of an event: moment at which a particular occurrence or an event occurs in a Xenograde System.

STATEMENT

When a collision occurs, the distance satellite-nucleus increases to the value of the distance at time T = 0. Then the satellite again approaches the nucleus.

DEMONSTRATION

Note that in the Table the distance increases to 48 after the collision. The maximum distance reached is the same as it was at the time T = 0.

Then, the distance decreases again.

F.F. = 14

T	ACN	BLIP TIME	DIST.	ACS
0	4		48	3
1	4		36	3
2	4		24	3
3	4		12	3
4	3	4	0	4
5	3		16	4
6	3		32	4
7	3		48	4
8	3		32	4

PRACTICE 1

F.F. = 3

T	ACN	BLIP TIME	DIST.	ACS
0	8		90	2
1	8		84	2
2	8		78	2
3	-		-	-
4	-		-	-
5	-		0	1
6	-		3	-

What will the maximum distance be after collision?

Answer: _____

TEST 1

F. F. = 2

T	ACN	BLIP TIME	DIST.	ACS
0	3		72	3
1	3		66	3

What will the maximum distance satellite-nucleus be after collision?

Answer: _____

TEST 2

F. F. = 4

T	ACN	BLIP TIME	DIST.	ACS
0	8		120	5
1	8		100	5
2	8		80	5

What will the maximum distance satellite-nucleus be after collision?

Answer _____

APPENDIX H

DESCRIPTION OF THE INSTRUCTIONAL MATERIALS

DESCRIPTION OF THE INSTRUCTIONAL MATERIALS

The study of the science of Xenograde will be made in 15 steps. The number for each step appears on the blue cards inside the box in front of you. For each step, a set of white cards explains the laws of the science of the Xenograde. The following is a description of what is found on the white cards for each of the steps.

Practice

The cards marked PRACTICE contain a question or a problem. The answers to these questions or problems are given on the last sheet of answers you will have. For example, you will read on a card PRACTICE:

> "What will the distance between the satellite and the nucleus of a Xenograde system be, if the mass of the nucleus is 3 grams, and the mass of the satellite is 4 grams?"

You will be able to check your answer by consulting the answer sheet.

Demonstration

The cards marked DEMONSTRATION give exemplifications. They describe, by means of specific cases, the parts of a Xenograde system and how to compute certain calculations. For example, on a card marked DEMONSTRATION it will be explained to you how to compute the distance between the nucleus and the satellite of a Xenograde system. You will read this on a DEMONSTRATION card:

"If the weight of the satellite is 3 grams and the weight of the nucleus is 2 grams, the distance that separates them will be obtained by multiplying 2 x 3 = 6."

Objective

The card marked OBJECTIVE will tell you what you will be able to do after studying each step. For example, you will read on an OBJECTIVE card:

"Be able to compute the distance between the satellite and the nucleus."

Statement

The card STATEMENT furnishes the information. It describes the different parts of a Xenograde system and indicates how to compute different calculations. For example, on one of these cards, it will be explained how to compute the distance between the nucleus and the satellite of a Xenograde system. You will read on the STATEMENT card:

"To determine the distance between the nucleus and the satellite multiply the weight of the nucleus by the weight of the satellite."

Skills to be Remembered

The card SKILLS TO BE REMEMBERED lists the previous knowledge tied up to the new knowledge to be learned.

If you were to learn how to compute the distance satellite-nucleus, the previous knowledge would be nucleus, satellite, distance satellite-nucleus, etc. The card SKILLS TO BE REMEMBERED would read, in this case, as follows:

"nucleus: particle that is located at the center of a Xenograde System;
satellite: particle that gravitates around the nucleus;
distance satellite-nucleus: distance that separates the nucleus from the satellite in a Xenograde System, etc."

Test

At the end of each step you will find 2 cards marked TEST. These cards contain, like the cards PRACTICE, questions or problems. You must fill out these 2 cards before going on to the next step. No response is given for these cards.

APPENDIX I

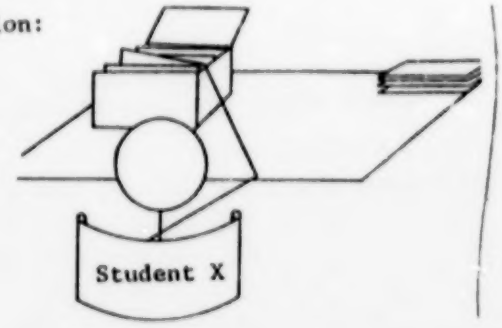
INSTRUCTION BOOKLETS

Instructions 1

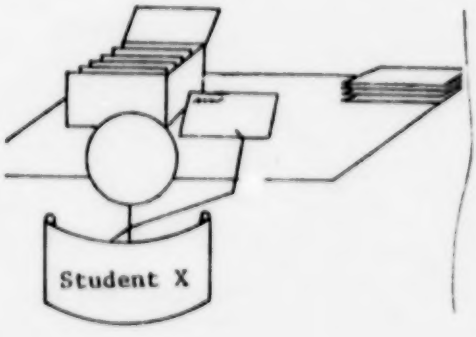
The concepts of the Xenograde science will be presented to you in 15 steps. For each particular step YOU ARE FREE TO CHOOSE THE NUMBER OF CARDS YOU WANT AND THE ORDER IN WHICH YOU WANT THEM. The only restriction is that YOU MUST FILL OUT THE TWO CARDS MARKED "TEST" ONLY AT THE END OF STUDYING ONE STEP.

Here is a detailed description:

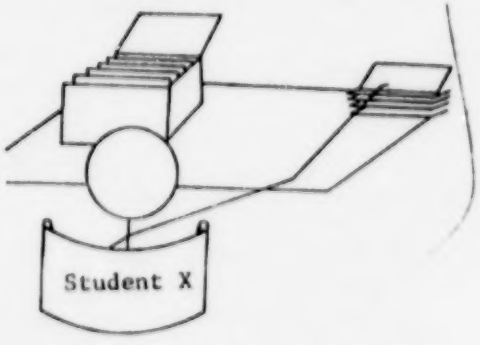
1. AT THE BEGINNING OF ONE STEP YOU CHOOSE ONE CARD.



2. YOU READ THAT CARD AND ANSWER THE QUESTION IF NECESSARY. YOU CHECK YOUR ANSWER WITH ONE ON THE ANSWER SHEET.



3. YOU PLACE THE CARD, FACE AGAINST THE DESK, ON TOP OF THE STACK. YOU THEN CHOOSE ANOTHER CARD THAT YOU WANT AND SO ON. WHEN YOU THINK YOU HAVE FINISHED STUDYING ONE STEP YOU ANSWER THE TWO TEST CARDS, YOU WILL PLACE THEM ON THE STACK AND START A NEW STEP.



IMPORTANT

1. You must study the step in order from 1 to 15 without skipping steps.

2. You should take one card at a time.

3. You should place the cards one on top of the other forming a stack, facing against the desk.

4. Pay attention not to mix the cards in the stack. If this happens, raise your hand and your instructor will tell you what to do in this case.

5. After placing a card on the stack, facing against the desk, you cannot re-read it. You must continue to read the cards that are in the box.

6. You must answer the cards PRACTICE and TEST on the cards themselves.

7. For each step there are generally:

   2 cards TEST

   3 cards PRACTICE

   3 cards DEMONSTRATION

   2 cards OBJECTIVE

   2 cards STATEMENT

   2 cards SKILLS TO BE REMEMBERED

   The two cards STATEMENT as well as the two cards OBJECTIVE and SKILLS TO BE REMEMBERED are identical. This is so as to allow you to review one or other card in case you wish to. It is not allowed to look at cards from another step when you are working on one particular step.

8. You may take as long as you want to complete the study of the science of Xenograde systems.

Now...

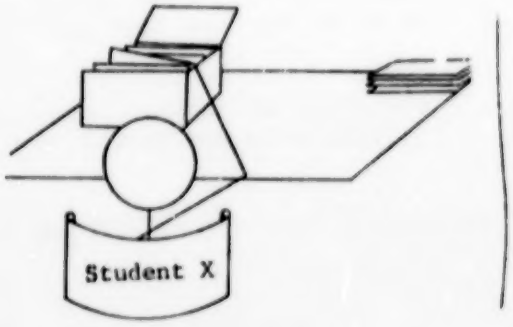
The following two pages contain a list of the names of each of the cards and the answers to the cards marked PRACTICE. (See pages 137-139.) Place them on your desk in a way you can see them easily. Check to be sure you have a pencil and the papers you will use during the course. Wait for the signal and then start the study of step 1.

Instructions 2

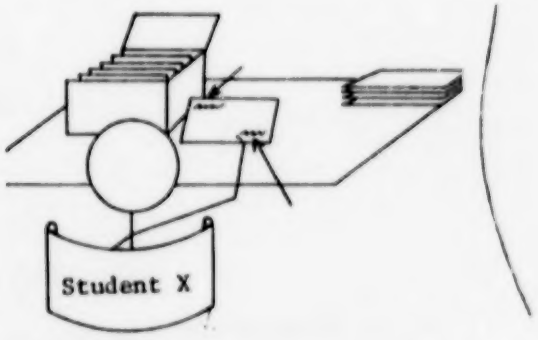
The concepts of the Xenograde science will be presented to you in 15 steps. For each particular step YOU HAVE TO STUDY THE CARDS IN THE ORDER WHICH WILL BE INDICATED TO YOU.

Here is a detailed description:

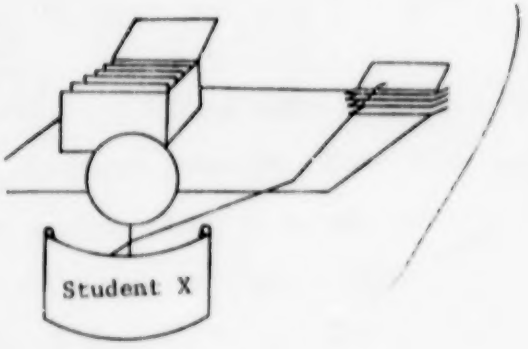
1. AT THE BEGINNING OF A STEP YOU TAKE THE CARD WHICH IS INDICATED TO YOU.



2. YOU READ THAT CARD AND ANSWER THE QUESTION IF NECESSARY. YOU CHECK YOUR ANSWER WITH THE ONE ON THE ANSWER SHEET.



3. YOU PLACE THE CARD, FACE AGAINST THE DESK, ON TOP OF THE STACK. YOU THEN TAKE THE CARD WHICH IS NAMED AT THE BOTTOM OF THE CARD YOU JUST READ.



IMPORTANT

1. You must study the steps in order from 1 to 15 without skipping steps.

2. You should take one card at a time.

3. You should place the cards one on top of the other forming a stack, facing against the desk.

4. Pay attention not to mix the cards in the stack. If this happens, raise your hand and your instructor will tell you what to do in this case.

5. After placing a card on the stack, facing against the desk, you cannot re-read it. You must continue to read the cards that are in the box.

6. You must answer the cards PRACTICE and TEST on the cards themselves.

7. For each step there are generally:

   2 cards TEST

   3 cards PRACTICE

   3 cards DEMONSTRATION

   2 cards OBJECTIVE

   2 cards STATEMENT

   2 cards SKILLS TO BE REMEMBERED

8. You may take as long as you want to complete the study of the science of Xenograde systems.

Now...

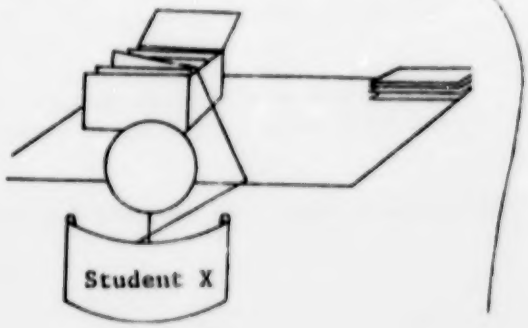
The following two pages contain a list of the names of each of the cards and the answers to the cards marked PRACTICE. Place them on your desk in a way you can see them easily. Check to be sure you have a pencil and the papers you will use during the course. Wait for the signal and then start the study of step 1 with the card OBJECTIVE.

Instructions 3

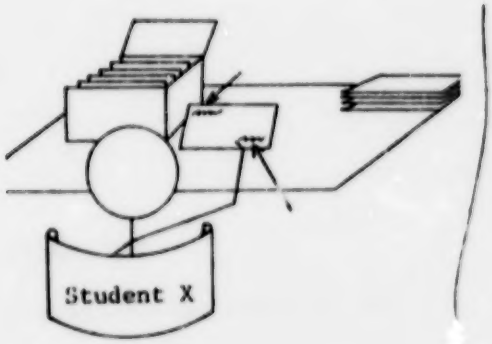
The concepts of the Xenograde science will be presented to you in 15 steps. For each particular step YOU HAVE TO STUDY THE CARDS IN THE ORDER WHICH WILL BE INDICATED TO YOU.

Here is a detailed description.

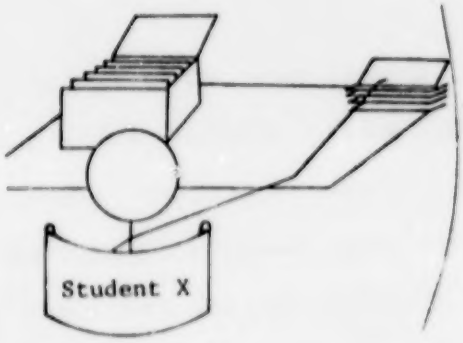
1. AT THE BEGINNING OF A STEP YOU TAKE THE CARD WHICH IS INDICATED TO YOU.



2 YOU READ THAT CARD AND ANSWER THE QUESTION IF NECESSARY. YOU CHECK YOUR ANSWER WITH THE ONE ON THE ANSWER SHEET.



3. YOU PLACE THE CARD, FACE AGAINST THE DESK, ON TOP OF THE STACK. YOU THEN TAKE THE CARD WHICH IS NAMED AT THE BOTTOM OF THE CARD YOU JUST READ.



IMPORTANT

1. You must study the steps in order from 1 to 15 without skipping steps.

2. You should take one card at a time.

3. You should place the cards one on top of the other forming a stack, facing against the desk.

4. Pay attention not to mix the cards in the stack. If this happens, raise your hand and your instructor will tell you what to do in this case.

5. After placing a card on the stack, facing against the desk, you cannot re-read it. You must continue to read the cards that are in the box.

6. You must answer the cards PRACTICE and TEST on the cards themselves.

7. For each step there are generally:

   2 cards TEST

   3 cards PRACTICE

   3 cards DEMONSTRATION

   2 cards OBJECTIVE

   2 cards STATEMENT

   2 cards SKILLS TO BE REMEMBERED

8. You may take as long as you want to complete the study of the science of the Xenograde Systems.

Now...

The following two pages contain a list of the names of each of the cards and the answers to the cards marked PRACTICE. Place them on your desk in a way you can see them easily. Check to be sure you have a pencil and the papers you will use during the course. Wait for the signal and then start the study of step 1 with the card STATEMENT.

APPENDIX J

POSTTEST

POSTTEST

QUESTION 1.5

DESCRIBE THE STATE OF THE XENOGRADE SYSTEM AT TIME T = 2

F.F. = 4

T	ACN	BLIP TIME	DIST.	ACS
0	8		64	1
1	8		60	1
2	8		56	1
3	8		52	1
4	8		48	1
5	8		44	1
6	8		40	1
7	8		36	1

Answer _____

QUESTION 2.11

WHAT ARE THE VALUES OF ACS AND ACN AT TIME T = 8?

F.F. = 2

T	ACN	BLIP TIME	DIST.	ACS
-	-		-	-
-	-		-	-
-	-		-	-
6	3		16	4
7	3		8	4
8	?	8	0	?

ACS: _____

ACN: _____

QUESTION 3.12

WHAT ARE THE VALUES OF ACN AND ACS AT TIME T = 3?

ACN: _____

ACS: _____

F.F. = 2

T	ACN	BLIP TIME	DIST.	ACS
0	3		24	4
1	3		16	4
2	3		8	4
3	?	3	0	?

QUESTION 4.14

WHAT ARE THE VALUES OF ACN AND ACS AT TIME T = 2?

ACN: _____

ACS: _____

F.F. = 4

T	ACN	BLIP TIME	DIST.	ACS
0	0		24	3
1	0		12	3
2	?		0	?

QUESTION 5.5

DESCRIBE THE STATE OF THE XENOGRADE SYSTEM AT TIME T = 4.

Answer _____

F.F. = 1

T	ACN	BLIP TIME	DIST.	ACS
0	6		60	3
1	6		57	3
2	6		54	3
3	6		51	3
4	6		48	3
5	6		45	3
6	6		42	3
7	6		39	3

QUESTION 6.4

AT WHAT TIME IS THE DISTANCE SATELLITE-NUCLEUS EQUAL TO 24?

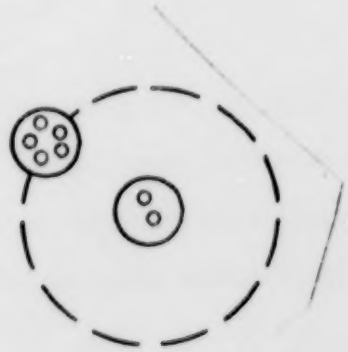
F.F. = 2

T	ACN	BLIP TIME	DIST.	ACS
0	3		60	6
1	3		48	6
2	3		36	6
3	3		24	6
4	3		12	6

Answer _____

QUESTION 7.1

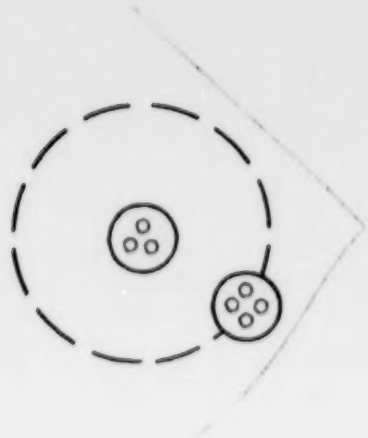
WHAT IS THE ACN OF THIS XENOGRADE SYSTEM?



Answer _____

QUESTION 8.1

WHAT IS THE ACN OF THIS XENOGRADE SYSTEM?



Answer _____

QUESTION 9.8

WHAT IS THE DISTANCE SATELLITE-NUCLEUS AT TIME T = 5?

F.F. = 3

T	ACN	BLIP TIME	DIST.	ACS
-			-	-
-			-	-
-			-	-
4	7		3	1
5			?	

Answer _____

QUESTION 10.3

CIRCLE THE NUMBER OF THE DESCRIPTION OF A F.F. OR FORCE FIELD.

1. THE F.F. IS A FORCE THAT INCREASES THE DISTANCE SATELLITE-NUCLEUS.
2. THE F.F. IS A FORCE THAT DECREASES THE DISTANCE SATELLITE-NUCLEUS.
3. THE F.F. IS A FORCE THAT CHANGES THE DISTANCE SATELLITE-NUCLEUS.
4. NONE OF THE ABOVE RESPONSES.

QUESTION 11.4

WHAT IS THE DISTANCE SATELLITE-NUCLEUS AT TIME T = 7?

F.F. = 1

T	ACN	BLIP TIME	DIST.	ACS
-			-	-
-			-	-
-			-	-
6	4		3	3
7				

Answer _____

QUESTION 12.6

WHAT IS THE BLIP TIME?

Answer _____

F.F. = 3

T	ACN	BLIP TIME	DIST.	ACS
0	3		30	2
1	3		24	2
2	3		18	2
3	3		12	2
4	3		6	2
5	4		0	1
6	4		3	1

QUESTION 13.11

WHAT ARE THE VALUES OF ACN AND ACS AT TIME T = 6?

ACS: _____

ACN: _____

F.F. = 3

T	ACN	BLIP TIME	DIST.	ACS
-	-		-	-
-	-		-	-
-	-		-	-
4	7		30	5
5	7		15	5
6	?		?	?

QUESTION 14.13

WHAT IS THE DISTANCE SATELLITE-NUCLEUS AT TIME T = 7?

Answer _____

F.F. = 4

T	ACN	BLIP TIME	DIST.	ACS
-			-	
-			-	
-			-	
4	8		40	5
5	8		20	5
6	7		0	6
7			?	

QUESTION 15.6

WHAT IS THE BLIP TIME?

Answer _____

F.F. = 2

T	ACN	BLIP TIME	DIST.	ACS
0	3		60	6
1	3		48	6
2	3		36	6
3	3		24	6
4	3		12	6
5	4		0	5
6	4		10	5
7	4		20	5

QUESTION 16.3

CIRCLE THE NUMBER OF THE DESCRIPTION OF A F.F. OR FORCE FIELD.

1. THE F.F. IS A FORCE THAT INCREASES OR DECREASES THE DISTANCE SATELLITE-NUCLEUS.
2. THE F.F. IS A FORCE THAT CHANGES THE ACN OF A XENOGRADE SYSTEM.
3. THE F.F. IS A FORCE THAT INCREASES THE ACN OF A XENOGRADE SYSTEM.
4. NONE OF THE ABOVE RESPONSES.

QUESTION 17.8

WHAT IS THE DISTANCE SATELLITE-NUCLEUS AT TIME T = 5?

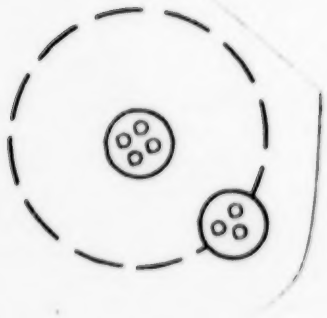
Answer _____

F.F. = 6

T	ACN	BLIP TIME	DIST.	ACS
-	-		-	-
-	-		-	-
-	-		-	-
4	3		12	1
5			?	

QUESTION 18.2

WHAT IS THE ACS OF THE FOLLOWING XENOGRADE SYSTEM?



Answer _____

QUESTION 19.4

AT WHAT TIME IS THE DISTANCE SATELLITE-NUCLEUS EQUAL TO 60?

F.F. = 3

T	ACN	BLIP TIME	DIST.	ACS
0	4		90	5
1	4		75	5
2	4		60	5
3	4		45	5
4	4		30	5
5	4		15	5

Answer _____

QUESTION 20.15

WHAT WILL THE MAXIMUM DISTANCE SATELLITE-NUCLEUS BE AFTER COLLISION?

F.F. = 3

T	ACN	BLIP TIME	DIST.	ACS
0	5		90	5
1	5		75	5
2	5		60	5

Answer _____

QUESTION 21.14

WHAT ARE THE VALUES OF ACN AND ACS AT TIME T = 6?

ACN: _____

ACS: _____

F.F. = 3

T	ACN	BLIP TIME	DIST.	ACS
-	0		-	-
-	0		-	-
-	0		-	-
3	0		45	5
4	0		30	5
5	0		15	5
6	?		0	?

QUESTION 22.9

WHAT IS THE DISTANCE SATELLITE-NUCLEUS AT TIME T = 5?

Answer: _____

F.F. = 3

T	ACN	BLIP TIME	DIST.	ACS
0	0		54	3
1	0		45	3
2	0		36	3
3	0		27	3
4	0		18	3
5	0		?	

QUESTION 23.9

WHAT IS THE DISTANCE SATELLITE-NUCLEUS AT TIME T = 4?

Answer _____

F.F. = 3

T	ACN	BLIP TIME	DIST.	ACS
0	7		90	2
1	7		84	2
2	7		78	2
3	7		72	2
4			?	

QUESTION 24.12

WHAT ARE THE VALUES OF ACN AND ACS AT TIME T = 3?

ACN: _____

ACS: _____

F.F. = 3

T	ACN	BLIP TIME	DIST.	ACS
0	3		36	4
1	3		24	4
2	3		12	4
3	?		0	?

QUESTION 25.10

WHAT ARE THE VALUES OF ACN AND ACS AT TIME T = 2?

ACN: _____

ACS: _____

F.F. = 3

T	ACN	BLIP TIME	DIST.	ACS
0	3		36	3
1	3		27	3
2	?			?

QUESTION 26.7

WHAT IS THE DISTANCE SATELLITE-NUCLEUS AT TIME T = 4?

Answer _____

F.F. = 1

T	ACN	BLIP TIME	DIST.	ACS
-			-	-
-			-	-
3	4		24	3
4			?	

QUESTION 27.10

WHAT ARE THE VALUES OF ACN AND ACS AT TIME T = 2?

ACN: _____

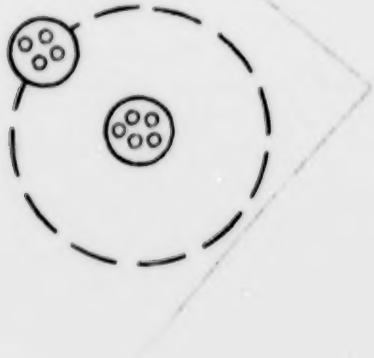
ACS: _____

F.F. = 2

T	ACN	BLIP TIME	DIST.	ACS
0	2		72	3
1	2		66	3
2	?		60	?

QUESTION 28.2

WHAT IS THE ACS OF THE FOLLOWING XENOGRADE SYSTEM?



Answer _____

QUESTION 29.15

WHAT WILL THE MAXIMUM DISTANCE SATELLITE-NUCLEUS BE AFTER COLLISION?

Answer _____

F.F. = 2

T	ACN	BLIP TIME	DIST.	ACS
0	7		60	5
1	7		50	5
2	7		40	5

QUESTION 30.13

WHAT IS THE DISTANCE SATELLITE-NUCLEUS AT TIME T = 7?

Answer _____

F.F. = 2

T	ACN	BLIP TIME	DIST.	ACS
-	-		-	-
-	-		-	-
-	-		-	-
4	5		8	2
5	5		4	2
6	4	6	0	3
7			?	

APPENDIX K

ATTITUDE TEST

ATTITUDE TEST

Throughout this experiment in Psychology of Learning you became acquainted with:

1. A fictitious science, the science of the Xenograde System.
2. A new way of learning (by means of a card system).

The following questionnaire intends to obtain your opinion about the way in which you have learned and not about the Xenograde systems themselves. That is, you will not be asked what you think about the science of the Xenogrades but about the way you learned it. This is not a test of information: there are no good or bad answers. Simply tell honestly if you agree or disagree with the statements here.

CIRCLE THE ANSWER THAT BEST REPRESENTS YOUR REACTION IN FACE OF EACH STATEMENT.

1. I did not have any difficulty in using the cards throughout the course.

Strongly disagree | Disagree | Uncertain | Agree | Strongly agree

2. Many school subjects would be interesting if presented by means of cards.

Strongly disagree | Disagree | Uncertain | Agree | Strongly agree

3. I found myself just trying to get through the material rather than trying to learn.

Strongly disagree | Disagree | Uncertain | Agree | Strongly agree

4. I felt lost with so many cards.

Strongly disagree | Disagree | Uncertain | Agree | Strongly agree

5. This way of learning (by means of cards) is inflexible.

Strongly disagree	Disagree	Uncertain	Agree	Strongly agree

6. I liked the way in which the course was organized.

Strongly disagree	Disagree	Uncertain	Agree	Strongly agree

7. I do not believe in the method of instruction utilized in this course.

Strongly disagree	Disagree	Uncertain	Agree	Strongly agree

8. I felt free to learn at my own pace.

Strongly disagree	Disagree	Uncertain	Agree	Strongly agree

9. I would have learned the concepts presented in much less time by other methods.

Strongly disagree	Disagree	Uncertain	Agree	Strongly agree

10. I liked the order in which I learned the different cards of a given step.

Strongly disagree	Disagree	Uncertain	Agree	Strongly agree

11. Even otherwise interesting material would be boring when presented this way.

Strongly disagree	Disagree	Uncertain	Agree	Strongly agree

12. I would have liked more explanations on how to use the cards.

Strongly disagree	Disagree	Uncertain	Agree	Strongly agree

13. I was uncertain of having mastered the content while answering the TEST cards.

Strongly disagree	Disagree	Uncertain	Agree	Strongly agree

14. I felt I was well prepared to take such a course.

Strongly disagree	Disagree	Uncertain	Agree	Strongly agree

15. The card system is easy to manipulate.

Strongly disagree	Disagree	Uncertain	Agree	Strongly agree

16. My impression about the course, after finishing it, is favorable.

Strongly disagree	Disagree	Uncertain	Agree	Strongly agree

17. I felt at ease studying by means of those cards.

Strongly disagree	Disagree	Uncertain	Agree	Strongly agree

18. The card system made me feel quite tense.

Strongly disagree	Disagree	Uncertain	Agree	Strongly agree

19. I felt at ease throughout the course.

Strongly disagree	Disagree	Uncertain	Agree	Strongly agree

20. I knew I would succeed in a TEST before answering it.

Strongly disagree	Disagree	Uncertain	Agree	Strongly agree

21. I was aware of efforts to suit the materials to my needs.

Strongly disagree	Disagree	Uncertain	Agree	Strongly agree

22. I do not think the order under which the cards were presented is valid.

Strongly disagree	Disagree	Uncertain	Agree	Strongly agree

23. I found it difficult to concentrate on the course material because of the card system.

Strongly disagree	Disagree	Uncertain	Agree	Strongly agree

24. This method of instruction is very effective.

Strongly disagree	Disagree	Uncertain	Agree	Strongly agree

25. I felt I was being forced to adopt a way of learning that is not my own.

Strongly disagree	Disagree	Uncertain	Agree	Strongly agree

26. I prefer the courses as they are presented traditionally to this card system.

Strongly disagree	Disagree	Uncertain	Agree	Strongly agree

27. I would enjoy having other courses presented under this card system.

Strongly disagree	Disagree	Uncertain	Agree	Strongly agree

28. The card system made it possible for me to learn quickly.

Strongly disagree	Disagree	Uncertain	Agree	Strongly agree

29. I would not be willing to take another course of this kind.

Strongly disagree | Disagree | Uncertain | Agree | Strongly agree

30. This card system is an inefficient use of student's time.

Strongly disagree | Disagree | Uncertain | Agree | Strongly agree

31. The way in which the course was organized made it easy for me to learn.

Strongly disagree | Disagree | Uncertain | Agree | Strongly agree

32. It was difficult for me to adapt myself to this type of course.

Strongly disagree | Disagree | Uncertain | Agree | Strongly agree

33. I felt frustrated by this card system.

Strongly disagree | Disagree | Uncertain | Agree | Strongly agree

34. In view of the amount I learned I would say that this method of instruction is superior to traditional instruction.

Strongly disagree | Disagree | Uncertain | Agree | Strongly agree

APPENDIX L

EXPECTATION OF MEAN SQUARES

AND F-RATIO

Expectation of Mean Squares and F-Ratio

Mean Squares	Expectation of Mean Squares	Fraction
Preparation, s_p^2	$\sigma_e^2 + Tn\,\sigma_{ac}^2 + CTn\,\sigma_a^2$	s_p^2/s_{pc}^2
Type of Control, s_t^2	$\sigma_e^2 + Pn\,\sigma_{ex}^2 + PCn\,\sigma_b^2$	s_t^2/s_{tc}^2
Classes, s_c^2	$\sigma_e^2 + n\,\sigma_{abc}^2 + CTn\,\sigma_c^2$	s_c^2/s_w^2
A X B, s_{pt}^2	$\sigma_e^2 + n\,\sigma_{abc}^2 + Cn\,\sigma_{ab}^2$	s_{pt}^2/s_{ptc}^2
A X C, s_{pc}^2	$\sigma_e^2 + Tn\,\sigma_{ac}^2$	s_{pc}^2/s_w^2
B X C, s_{tc}^2	$\sigma_e^2 + Pn\,\sigma_{bc}^2$	s_{tc}^2/s_w^2
A X B X C, s_{ptc}^2	$\sigma_e^2 + n\,\sigma_{abc}^2$	s_{ptc}^2/s_{ptc}^2
Within Cells, s_w^2	σ_e^2	

Note. Preparation for learning and type of control are fixed factors, classes are random.

APPENDIX M

PATTERNS SELECTED BY THE CHILDREN

GROUP A

RXPO	XRP	RXPO	RXPO	RXPO	R	RXPO
ROPX	XRP	RXPO	XPRO	XPRO	PXRO	XPRO
XROP	XPOR	RXOP	XOPR	RXOP	RXOP	RXOP
RXOP	XR	PROX	PXRO	PRXO	PRXO	PRXO
RXOP	XPR	XR	OPXR	XOPR	XOR	XOPR
RPOX	OXPP	RXOP	OPXR	RPOX	POXR	RPOX
RXPO	OXRP	XPO	RXPO	RXPO	RXPO	RXPO
PXRO	OXR	RPXO	PXRO	PXRO	PXRO	PXRO
RPXO	XR	ORPX	POXR	PXOR	PXOR	PXOR
OXRP	OXR	XROP	OXRP	OXRP	OXRP	OXRP
RXOP	POXR	RPOX	ORX	RXOP	RXOP	RXOP
RXOP	POXR	RPXO	XROP	XROP	XROP	XROP
PROX	PPOX	RXPO	PROX	PROX	PROX	PROX
PXOR	RPOX	RPXO	RXOR	PXOR	PXOR	PXOR
OPXR	ROPX	PXRO	OPXR	OPXR	OPXR	OPXR

RXPO	XRPO	RXPO	RXPO	RXPO	RXP	ORXP
XPRO	XPRO	XPRO	PXOR	XPRO	XPRO	OPXR
RXOP	XOPR	RXOP	RXOP	RXOP	POXR	XOPR
PRXO	OPXR	PRXO	PRXO	PRXO	OPXR	PRXO
XOPR	OPXR	XOPR	XOPR	XOPR	OXPR	XOPR
RPOX	OPXR	RPOX	RPOX	PO	POXR	POXR
RXPO	OPXR	RXPO	RXPO	POXR	POXR	XPOR
PXRO	OPXR	PXRO	PXRO	PXRO	PXRO	OXRP
PXOR	OPXR	PXOR	PXOR	POXR	POXR	PXOR
OXRP	OPXR	OXRP	OXRP	OXRP	OPXR	OXRP
RXOP	OPXR	RXOP	RXOP	OPXR	OPXT	RXOP
XPOR	OPXR	XROP	XROP	XROP	OPXR	OPRX
PROX	OPXR	PROX	PROX	PROX	POXR	OXPR
PXOR	OPXR	PXOR	PXOR	PXOR	POXR	PXOR
OPXR	OPXR	OPXR	OPXR	OPXR	OPXR	OPXR

RXPO	RXPO	XRPO	RXPO	RXPO
XPRO	PXO	XPRO	XPRO	XPRO
RXOP	RXOP	POXR	RXOP	RXOP
PRXO	RPXO	PRXO	PRXO	PRXO
XOPR	RPXO	XOPR	XOPR	XOPR
RPOX	RXPO	PXR	POXR	RPOX
RXPO	R	XPOR	XPOR	RXPO
PXRO	ROPX	PXRO	PXRO	PXRO
PXOR	ROXP	PXOR	PXOR	PXOR
OXRP	ROXP	OXRP	OXR	XRP
RXOP	RXOP	XOPR	OPRX	RXOP
XROP	XROP	XROP	XRO	XROP
PROX	XORP	POXR	RX	PROX
PXOR	PXOR	PXOR	R	PXOR
OPXR	OPXR	OPXR	OXR	OPXR

GROUP B

RXPO	RXPO	XPOR	RXPO	XR	RXPO	RXPO
XPRO	XPRO	XPRO	XPRO	RO	XPRO	XPRO
RXPO	ROPX	XORP	RXOP	RX	RXOP	RXOP
PRXO	PRXO	XOPR	PRXO	PR	PXOR	PRXO
XOPR	XOPR	XOPR	XOPR	XR	XOPR	XOPR
RPOX	RPOX	POXR	RPOX	XR	RPOX	POXR
RXPO	RXPO	XPOR	RXPO	XR	RXPO	RPOX
PXRO	PXOR	OXPR	PXRO	XRO	PXRO	PXRO
PXOR	PXOR	PXOR	PXOR	R	PXOR	PXOR
OXRP	OXPR	XPOR	OXRP	XR	OXRP	OXRP
RXOP	RXOP	XOPR	RXOP	XRO	RXOP	RXOP
XROP	XROP	XROP	XROP	RO	XROP	XROP
PROX	PROX	PXOR	PROX	OR	PROX	PROX
PXOR	PXOR	PXOR	PXOR	XRO	PXOR	PXOR
OPXR	OPXR	XOPR	OPXR	OR	OPXR	OPRX

RXPO	RXPO	RXPO	XRPO	RXOP	RXOP	RXPO
XPRO	XPRO	XPRO	XPRO	RXOP	XPRO	XPRO
RXOP	RXOP	RXOP	RXOP	RXOP	XRPO	XPRO
PRXO	PRXO	PRXO	PORX	RXOP	PRXO	PXOR
XOPR	XOPR	XOPR	OXPR	RXOP	XOPR	XOPR
RPOX	RPOX	RPOX	RPOX	RXOP	PROX	POXR
RXPO	RXPO	RXPO	RXPO	RXOP	RXPO	XPOR
PXRO	PXRO	PXRO	PXRO	RXOP	PRXO	PXRO
PXOR	PXOR	PXOR	PXOR	RXOP	PXOR	XPOR
OXRP	OXRP	OXRP	OXRP	RXOP	OXRP	OXRP
RXOP	RXOP	RXCP	RXOP	RXOP	RXOP	OXRP
XROP	XROP	XROP	XROP	POXR	XROP	XROP
PROX	PROX	PROX	PROX	RXOP	PROX	XROP
PXOR	PXOR	PXOR	XPOR	RXOP	PXOR	POXR
OPXR	OPXR	OPXR	OPXR	RXOP	OPXR	OPXR

RXPO	RXPO	XRPO	RXPO	RXPO
XPRO	XPRO	XPRO	XPRO	XPRO
RXOP	POXR	RXOP	RXOP	RXOP
RPXO	PRXO	PXR	PRXO	PRXO
XOPR	XOPR	XR	XOPR	XOPR
POXR	RPOX	XRPO	RPOX	RPOX
XPOR	RXPO	XR	RXPO	RXPO
PXOR	PXRO	XR	PXRO	PXRO
PXOR	PXOR	R	PXOR	PXRO
OXRP	OXRP	R	OXRP	OXRP
XOPR	RXOP	R	RXOP	RXOP
XROP	XROP	XR	XROP	XROP
PROX	PROX	R	PROX	PROX
PXOR	PXOR	R	PXOR	PXOR
OPXR	OPXR	R	OPXR	OPXR

APPENDIX N

MATRIX OF POSSIBLE PATTERNS

MATRIX OF POSSIBLE PATTERNS

(1)	O	P	X	R
(2)	O	P	R	X
(3)	O	X	P	R
(4)	O	X	R	P
(5)	O	R	P	X
(6)	O	R	X	P
(7)	P	O	X	R
(8)	P	O	R	X
(9)	P	X	O	R
(10)	P	X	R	O
(11)	P	R	O	X
(12)	P	R	X	O
(13)	X	O	P	R
(14)	X	O	R	P
(15)	X	P	O	R
(16)	X	P	R	O
(17)	X	R	O	P
(18)	X	R	P	O
(19)	R	O	P	X
(20)	R	O	X	P
(21)	R	P	O	X
(22)	R	P	X	O
(23)	R	X	O	P
(24)	R	X	P	O

APPENDIX O

MATRICES OF FREQUENCIES

GROUP A

Matrices of Frequencies of Various Patterns of Choice (columns)
For Each Skill (rows)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Skill 1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	13
Skill 2	1	0	0	0	0	0	0	0	1	1	0	0	0	0	1	11	1	0	1	0	0	0	0	1
Skill 3	0	0	0	0	0	0	2	0	0	0	0	0	3	0	1	1	0	0	0	0	0	0	12	0
Skill 4	2	0	0	0	0	0	0	0	0	1	1	12	0	0	0	0	0	0	0	0	0	1	1	0
Skill 5	2	0	1	0	0	0	0	0	0	0	0	0	11	0	0	0	0	0	0	0	0	1	1	0
Skill 6	2	0	1	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0	1	1
Skill 7	1	0	0	1	0	0	2	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	10
Skill 8	1	0	0	1	0	0	0	0	0	14	0	0	0	0	0	0	0	0	1	0	0	1	0	0
Skill 9	1	0	0	0	1	0	3	0	11	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0
Skill 10	2	0	0	12	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0
Skill 11	3	1	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	11	0
Skill 12	2	1	0	0	0	0	1	0	0	0	0	0	0	0	1	0	11	0	0	0	0	0	1	0
Skill 13	1	0	1	0	0	0	2	0	0	0	11	0	0	1	0	0	0	0	0	0	0	0	0	1
Skill 14	1	0	0	0	0	0	1	0	14	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0
Skill 15	16	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Total	19	2	3	2	1	1	16	0	1	3	1	0	4	1	6	0	2	2	3	2	2	6	4	3

Note: The largest number in each row corresponds to the number of times the pattern of cards as presented in a file box has been adopted. Incomplete patterns were not considered in the analysis.

GROUP B

Matrices of Frequencies of Various Patterns of Choice (columns) For Each Skill (rows)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Skill 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	2	0	0	0	0	2	13
Skill 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17	0	0	0	0	0	0	1	0
Skill 3	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	1	0	1	1	0	0	0	13	0
Skill 4	0	0	0	0	0	0	0	1	2	0	0	11	1	0	0	0	0	0	0	0	0	1	1	0
Skill 5	0	0	1	0	0	0	0	0	0	0	0	0	15	0	0	0	0	0	0	0	0	0	1	0
Skill 6	0	0	0	0	0	0	4	0	0	0	1	0	0	0	0	0	0	1	0	0	12	0	1	0
Skill 7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	1	0	1	12
Skill 8	0	0	1	0	0	0	0	0	2	12	0	1	0	0	0	0	0	0	0	0	0	0	1	0
Skill 9	0	0	0	0	0	0	0	0	14	1	0	0	0	0	1	0	0	0	0	0	0	0	1	0
Skill 10	0	0	1	14	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0
Skill 11	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	1	0	0	0	0	0	14	0
Skill 12	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	15	0	0	0	0	0	0	0
Skill 13	0	0	0	0	0	0	1	0	1	0	14	0	0	0	0	0	0	0	0	0	0	0	1	0
Skill 14	0	0	0	0	0	0	0	14	0	0	0	0	0	0	2	0	0	0	0	0	0	0	1	0
Skill 15	14	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0
Total	0	1	3	0	0	0	7	1	5	1	1	1	5	1	8	1	1	2	1	0	1	1	13	0

Note: The largest number in each row corresponds to the number of times the pattern of cards as presented in a file box has been adopted. Incomplete patterns were not considered in the analysis.

BIBLIOGRAPHY

BIBLIOGRAPHY

Atkinson, A.C. Models of memory. In F. Bresson and M. de Montmollin (Eds.), Programmed learning research: Major trends (Vol. 8). Paris: Dunod, 1969.

Belmont, J.M. and Butterfield, E.C. What the development of short-term memory is. Human Development, 1971, 14, 236-248.

Bower, G. H. Cognitive psychology: An introduction. W.K Estes (Ed.) Handbook of learning and cognitive processes (Vol. 1). Hillsdale, New Jersey: Laurence Erlbaum Associates, 1975.

Brown, B.R. An Instrument for the measurement of expressed attitude toward computer-assisted instruction. In Semi-annual progress report, experimentation with computer-assisted instruction (Project No. 5-85-974, prepared by H.E. Mitzel, et al.) State College, Penn.: State University, December 1966.

Campbell, V.N. Self-direction and programmed instruction for five different types of learning objectives. Psychology in the Schools, 1964, 1 (4), 348-359.

Campbell, V.N. and Chapman, M A. Learner control vs. program control of instruction. Psychology in the Schools, 1967, 4 (2).

Crutchfield, R.S. and Covington, M.V. Programmed instruction and creativity. Programmed Instruction, 1965, 4, 2-10.

Flavell, J.H. Metacognitive aspects of problem solving. In L.B. Resnick (Ed.), The nature of intelligence. New York: John Wiley and Sons, 1976.

Flavell, J.H., Beach, D.H. and Chinsky, J.M. Spontaneous verbal rehearsal in a memory task as a function of age. Child Development, 1966, 36, 283-299.

Flavell, J.H., Friedricks, A.G. and Hoyt, J.P. Developmental changes in memorization processes. Cognitive Psychology, 1970, 1, 324-340.

Gagné, R.M. The acquisition of knowledge. Psychological Review, 1962, 69, 355-365 (a).

Gagné, R.M. Military training and principles of learning. American Psychologist, 1962, 17, 83-91 (b).

Gagné, R.M. The conditions of learning. (2nd edition). New York: Holt, Rinehart and Winston, 1970.

Gagné, R.M. Domains of learning. Interchange, 1972, 3, 1-8.

Gagné, R.M. Essentials of learning for instruction. New York: Holt, Rinehart and Winston, 1974.

Gagné, R.M. and Briggs, L.J. Principles of instructional design. New York. Holt, Rinehart and Winston, 1974.

Gibbons, J.D. Nonparametric methods for quantitative analysis. New York: Holt, Rinehart and Winston. 1976.

Graubard, A. Free the children. New York: Vintage Books, 1972.

Grubb, R.E. Learner-controlled statistics. Programmed Learning and Educational Technology, 5, 1968.

Judd, W.A., O'Neil, H.F. and Spelt, P.F. Individual differences and learner control I: Program development and investigation of control over memories in computer-assisted instruction (Tech. Rep. 27). Austin: The University of Texas, Computer Assisted Instruction Laboratory, 1974.

Judd, W.A. Learner-controlled computer-assisted instruction. Paper presented at the International School on Computer in Education, Pugnochiuso, Italy, July 1972.

Lahey, F. and Crawford, A.M. Learner control of lessons strategy: Some tentative results. Paper presented at the Annual Meeting of the American Educational Research Association, San Francisco, April 1976.

Mager, R.F. On the sequencing of instructional content. Psychological Reports, 1961, 9, 405-413.

Mager, R.F. and Clark, C. Explorations in student-controlled instruction. Psychological Reports, 1963, 13, 71-76.

Masur, E.F., McIntyre, C.W. and Flavell, J.H. Developmental changes in apportionment of study time among items on a multi-trial free recall task. Journal of Experimental Child Psychology, 1973, 15, 237-246.

McCann, P.H., Lahey, G.F. and Jurlock, R.E. A comparison of student option vs. program controlled CAI training (Tech. Rep. Srr 73-17). San Diego: Naval Personnel and Training Research Laboratory, April, 1973.

Merrill, M.D. and Boutwell, R.C. Instructional development: Methodology and research. In F.N. Kerlinjer (Ed.). Review of research in education: 1 Itasca, Ill: Peacock, 1973.

Merrill, M.D. Learner Control: Beyond aptitude-treatment interactions. Audio-Visual Communication Review, 2, Summer, 1975.

Merrill, P.F. Interaction of cognitive abilities with availability of behavioral objective in learning a hierarchical task by computer-assisted instruction (Tech. Rep. 5). Austin: The University of Texas: Computer-Assisted Instruction Laboratory, May 1970.

Neimark, E., Slotnick, N.S. and Ulrick, T. The development of memorization strategies. Developmental Psychology, 1971, 5, 427-432.

Newell, A. and Simon, H.A. Human problem solving. Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1972.

Newkirk, R.L. A comparison of learner control and machine control strategies for computer-assisted instruction. Programmed Learning, 1973, 82-91.

Norman, B.A. Models of human memory. New York: Academic Press, 1970.

O'Neil, F. Learner control of instruction: Requirements and potentials (Tech. Rep. 2). Provo: Brigham Young University, Institute for Computer Uses in Education, 1973.

Olivier, W.P. Learner and program-controlled sequences of computer-assisted instruction. Paper presented at the annual meeting of the American Educational Reserach Association, New York, February 1971.

Resnick, L.B. and Glaser, R. Problem solving and intelligence. In L.B. Resnick (Ed.), The nature of intelligence. New York: John Wiley & Sons, 1976.

Ritter, K., Kaprove, B. H., Fitch, J. P. and Flavell, J. H. The development of retrieval strategies in young children. Cognitive Psychology, 1973, 5, 310-321.

Rohwer, W. D., Jr. Elaboration and learning in childhood and adolescence. In H. W. Reese (Ed.), Advances in child development and behavior (Vol. 8). New York: Academic Press, 1974.

Rothkopf, E.Z. Some Conjectures about inspection behavior in learning from written sentences and the response mode problem in programmed self-instruction. Journal of Programmed Instruction, 1963, 2, 31-46.

Rothkopf, E.Z. Learning from written materials: An exploration of the control of inspection behavior by test-like events. American Educational Research Journal, 1966, 3, 241-249.

Rothkopf, E.Z. Two scientific approaches to the management of instruction. In R.M. Gagne and W.J. Gephart (Eds.), Learning research and school subjects. Itasca, Ill.: F.E. Peacock, 1968.

Rothkopf, E.Z. The concept of mathemagenic activities. Review of Educational Research, 1970, 40, 325-336.

Salatas, H. and Flavell, J.H. Retrieval of recently learned information: Development of strategies and control of skills. Minnesota: University of Minnesota, Institute of Child Development, 1975.

Thiagaragan, S. [Programme sur le processus de programmation] (Champagne, M., Fournier, J.P. and Parent, J., Eds. and trans.) Montreal: Lidec, 1971. (Originally published in 1971).

Tversky, B. Encoding processes in recognition and recall. Cognitive Psychology, 1973, 5, 275-287.

Winer, B.J. Statistical principles in experimental design (2nd edition). New York: McGraw-Hill Book Company, 1971.

VITA

Robert Brien was born on August 10, 1941, in Joliette, Province of Quebec, Canada. In 1963 he received a License of Science degree from Laval University with a major in mathematics. In 1972 he was awarded the degree of Master of Science in instructional technology from the same university. In 1977 he received a Ph.D. in Instructional Design and Development from the Florida State University.

From 1963 to 1968 he taught mathematics and physics at the College of La Pocatiere and in two high schools of Quebec City, Canada. From 1969 to 1972 he worked as a subject-matter specialist in the design and development of computerized mathematics courses at the Computer-Assisted Instruction Laboratory of the Ministry of Education in Quebec City. From 1972 to 1974 he worked as a professor of programmed instruction and computer-assisted instruction at the Instructional Technology Department of the Faculty of Education of Laval University in Quebec City.

He is a member of the American Educational Research Association and of the National Society for Performance

and Instruction. His primary career interest is in the design and development of instructional systems and the training of educators in instructional systems development.